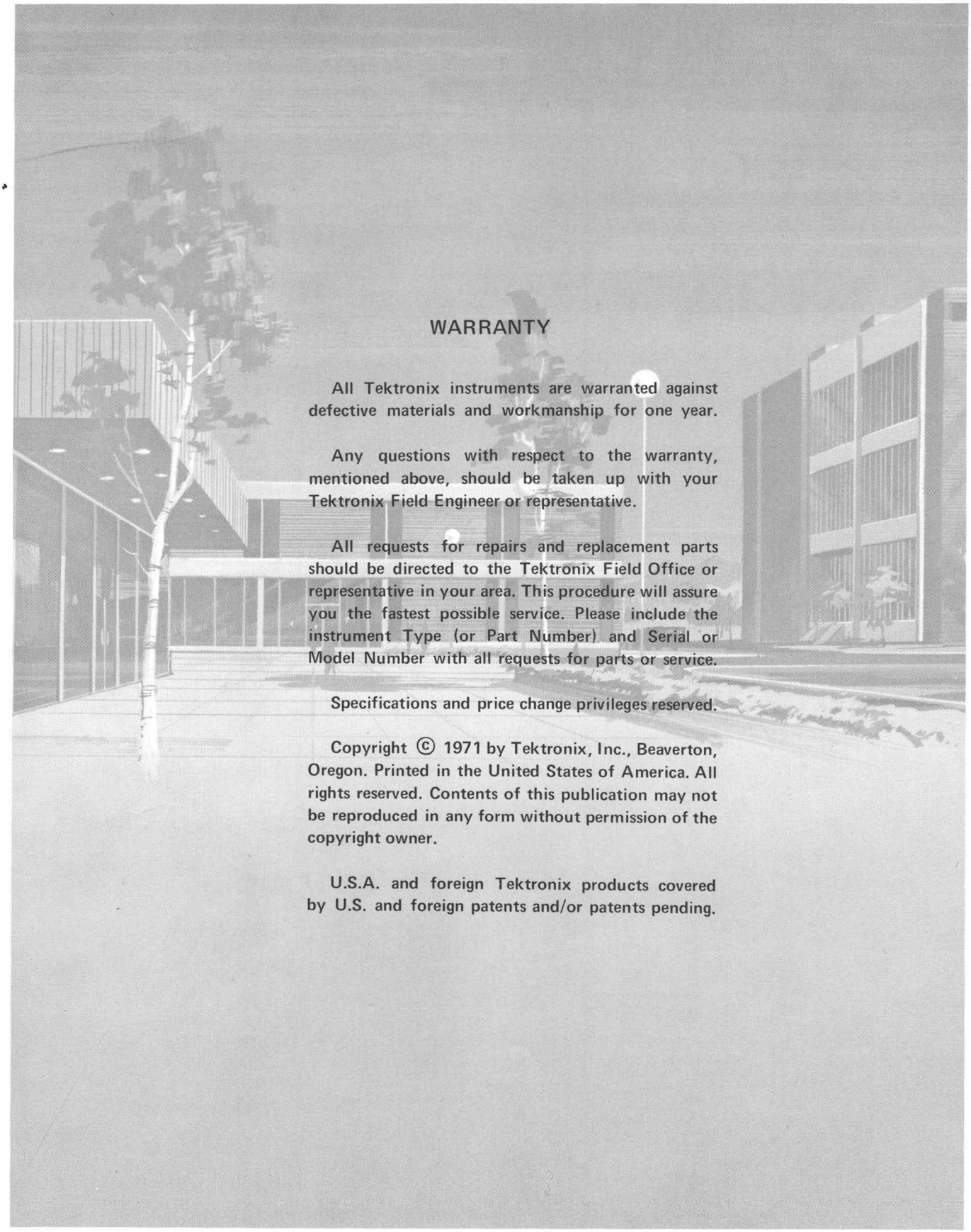
INSTRUCTION MANUAL

Serial Number B060449

TYPE 4501
SCAN CONVERTER UNIT
SN B100000—up

Tektronix, Inc. ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-1158-00



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year.

Any questions with respect to the warranty, mentioned above, should be taken up with your Tektronix Field Engineer or representative.

All requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type (or Part Number) and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

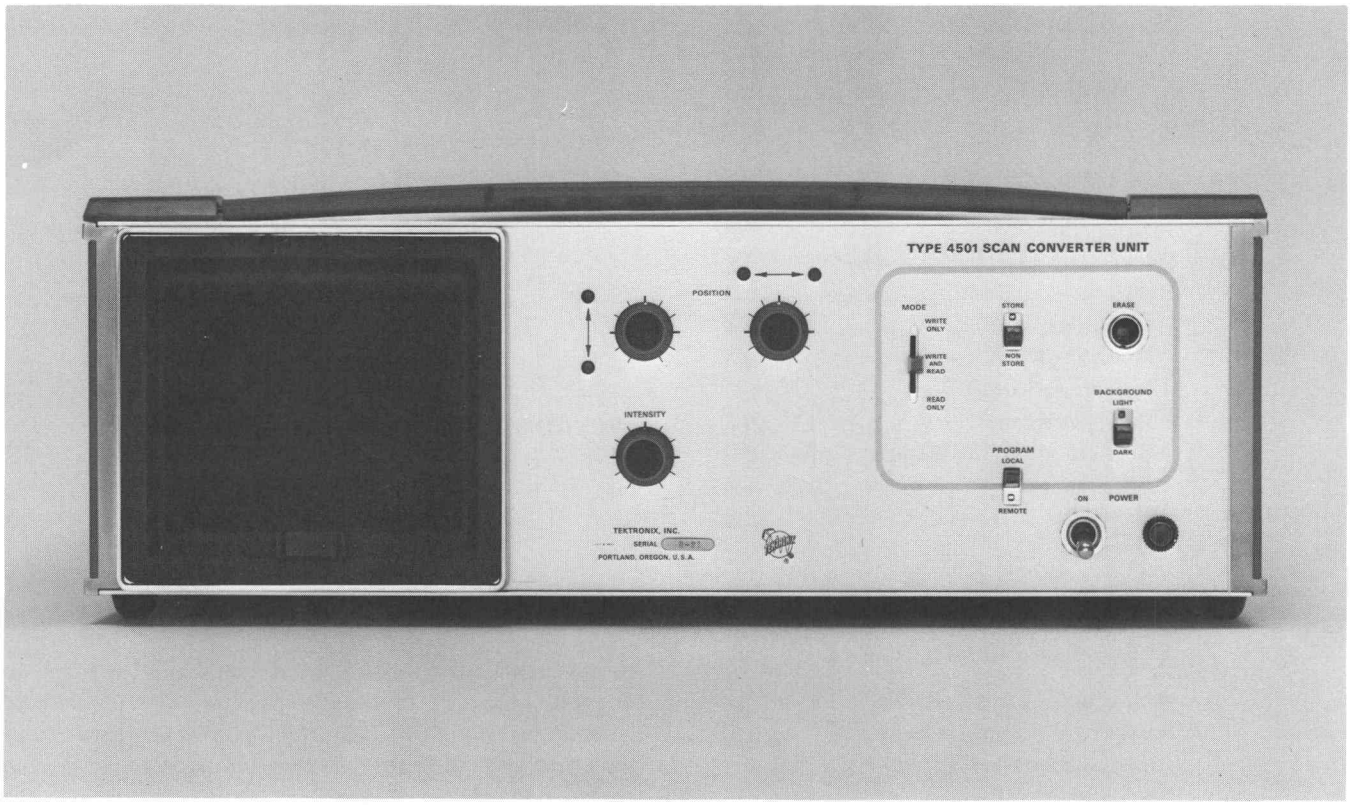
U.S.A. and foreign Tektronix products covered by U.S. and foreign patents and/or patents pending.

TABLE OF CONTENTS

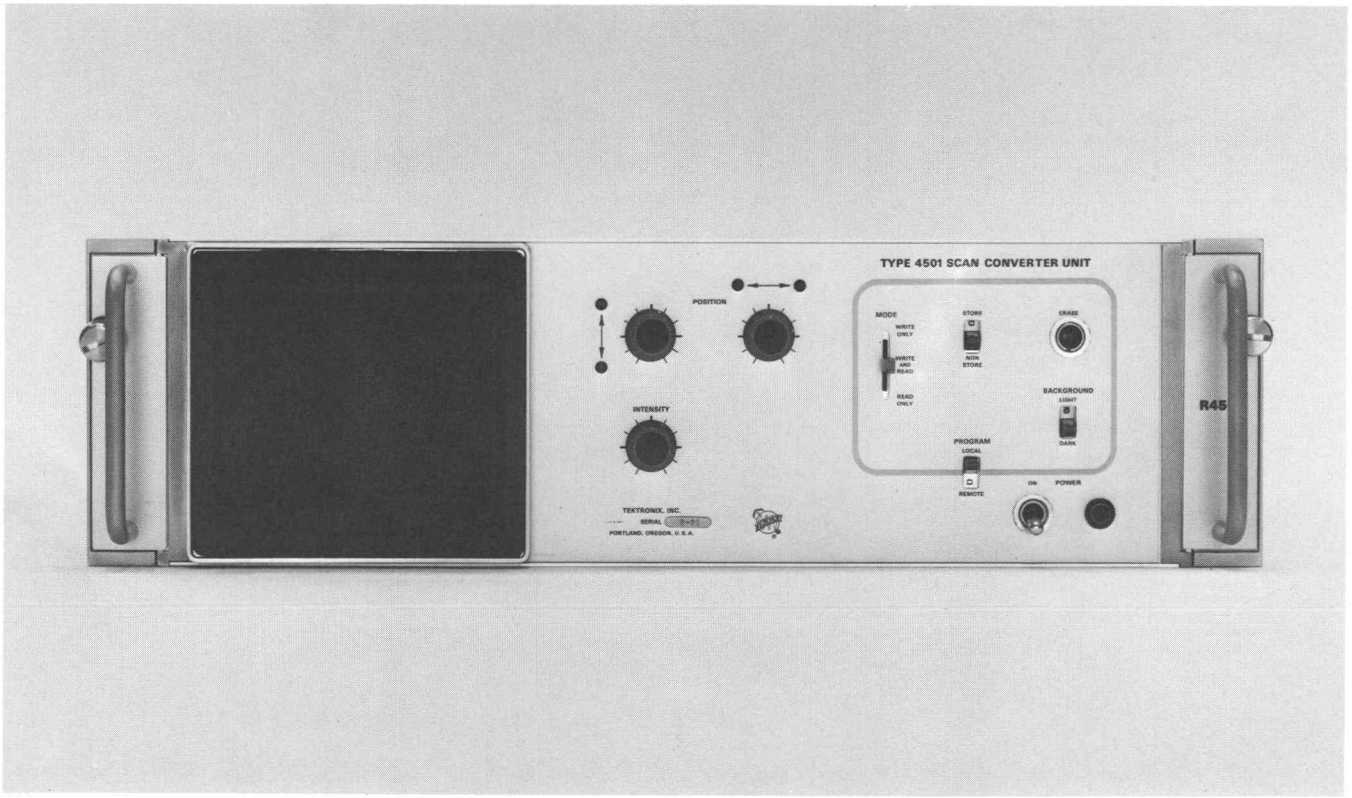
CONTENTS (cont)

CONTENTS (cont)

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.



(A) The Type 4501 Scan Converter (bench model).



(B) The Type R4501 Scan Converter (rackmount model).

Fig. 1-1. The two models of the Scan Converter are electrically identical. Mechanical parts are available from Tektronix, Inc. to permit easy field conversion from one type to the other (see Section 9).

SECTION 1
SPECIFICATION

Change information, if any, affecting this section will be found at the rear of the manual.

General Information

The Type 4501 Scan Converter Unit[1] provides a graphical storage medium with write-in and read-out scanning electronics. The Type 4501 is designed to provide large screen displays of graphic and alphanumeric data written on its storage CRT. Information is both written and read by a time-shared electron beam. Uses include displaying data symbols, graphs, facsimile images, industrial process monitoring, biophysical monitoring, education and training, computer display and other applications where a TV display is desired.

NOTE

The Type 4501 **WILL NOT OPERATE CORRECTLY** *unless a number of circuit interconnections are supplied through Remote Program Connector J1304 mounted on the rear panel. Install the loop through adapter (Tektronix Part No. 013-0108-00) on J1304 when no external programming connection is made.*

Write-in is accomplished through three information input channels and a switching logic matrix. The X and Y channels correspond to the axis of a cartesian coordinate plot with an aspect ratio of 4:3, matching the TV frame. The Z-axis channel controls the writing beam intensity. All three channels have direct coupled differential inputs.

Read-out is accomplished by scanning the CRT storage target with a TV raster. The Type 4501 develops the necessary TV sync, blanking and raster, and combines the sync and video to assemble a composite TV picture signal. A video picture monitor and/or broadcast TV receiver can be used to display the picture at 525/60 or 625/50 scan rates, internally selectable. Both 31.5 kHz and 31.25 kHz cyrstals are standard and normally supplied. Crystal control is necessary when master sync sources are not available. External sync and blanking are automatically utilized when connected to the Type 4501.

ELECTRICAL CHARACTERISTICS

The following performance requirements are valid over the stated environmental range for instruments calibrated at an ambient temperature of +20°C to +30°C. A 30 minute warmup is required for rated accuracies. All input connectors not used should have the ground cap connected.

[1] **Since the two models of the Scan Converter are electrically identical, the Type 4501 is used for text and R4501 is used for illustrations in this manual unless noted otherwise.**

VERTICAL & HORIZONTAL AMPLIFIERS

Characteristic	Performance Requirement
Deflection Factors	
Vertical (Y)	750 mV full screen (7.5 cm), variable from 375 mV full screen to 1.125 V full screen with internal adjustment.
Horizontal (X)	1 V full screen (10 cm), variable from 0.5 V full screen to 1.5 V full screen with internal adjustment.
Polarity Sense	
+Y Input	Positive-going signal moves beam up
−Y Input	Negative-going signal moves beam up
+X Input	Positive-going signal moves beam right
−X Input	Negative-going signal moves beam right
Maximum Input Voltage	±200 V, DC plus peak AC
Gain Stability	Within 1% of gain setting, +20°C to +30°C Within 4% of gain setting, 0°C to +50°C
Position Stability	Within 10 mV of graticule center, +20°C to +30°C Within 50 mV of graticule center, 0°C to +50°C
Linear Common Mode Signal Range	+ and −2.5 V, total not to exceed 5 V P-P
Common Mode Rejection Ratio	At least 500:1 at 10 kHz At least 100:1 at 1 MHz At least 10:1 at 10 MHz
Dot Settling Time (To Within 1% of Final Position)	0.15 µs or less

Characteristic	Performance Requirement
Phase Difference	Within 10° between X and Y at 10 MHz
Vertical and Horizontal Position Ranges	Any portion of + and −1 V signal (2 V P-P) may be positioned to center of graticule
Risetime (10% to 90%)	50 ns or less risetime with a half-scale (3.75 cm) positive-going step input
Aberrations	Within 5% of pulse amplitude
Bandwidth (X and Y)	At least 10 MHz 20°C to 30°C within central 7.5 cm vertical and horizontal scan area
Input Resistance	1 MΩ within 2%
Input Capacitance	Input capacitance 40 pF to 50 pF

Z AMPLIFIER

Characteristic	Performance Requirement
Linear Input Mode	
Input Amplitude	+1 V difference between +Z and −Z for maximum intensity 0.5 V for normal intensity
Maximum Safe Input	±200 V, DC plus peak AC
Common Mode Signal Range	+ and −2.5 V, total not to exceed 5 V P-P
DC Offset Capability	Intensity control can override input signal amplitudes of +1 V difference between +Z and −Z
Limiting Input Mode	
On (Beam Writing)	+1 V to +10 V difference between +Z and −Z for turn on
Off (Beam Off)	+0.5 V to −10 V difference between +Z and −Z for turn off
Common Mode Signal Range	±10 volts (DC plus AC)
Minimum Pulse Width	200 ns
Maximum Safe Input	±200 V, DC plus peak AC
Polarity Sense	
+Z Input	Positive-going signal increases intensity
−Z Input	Negative-going signal increases intensity

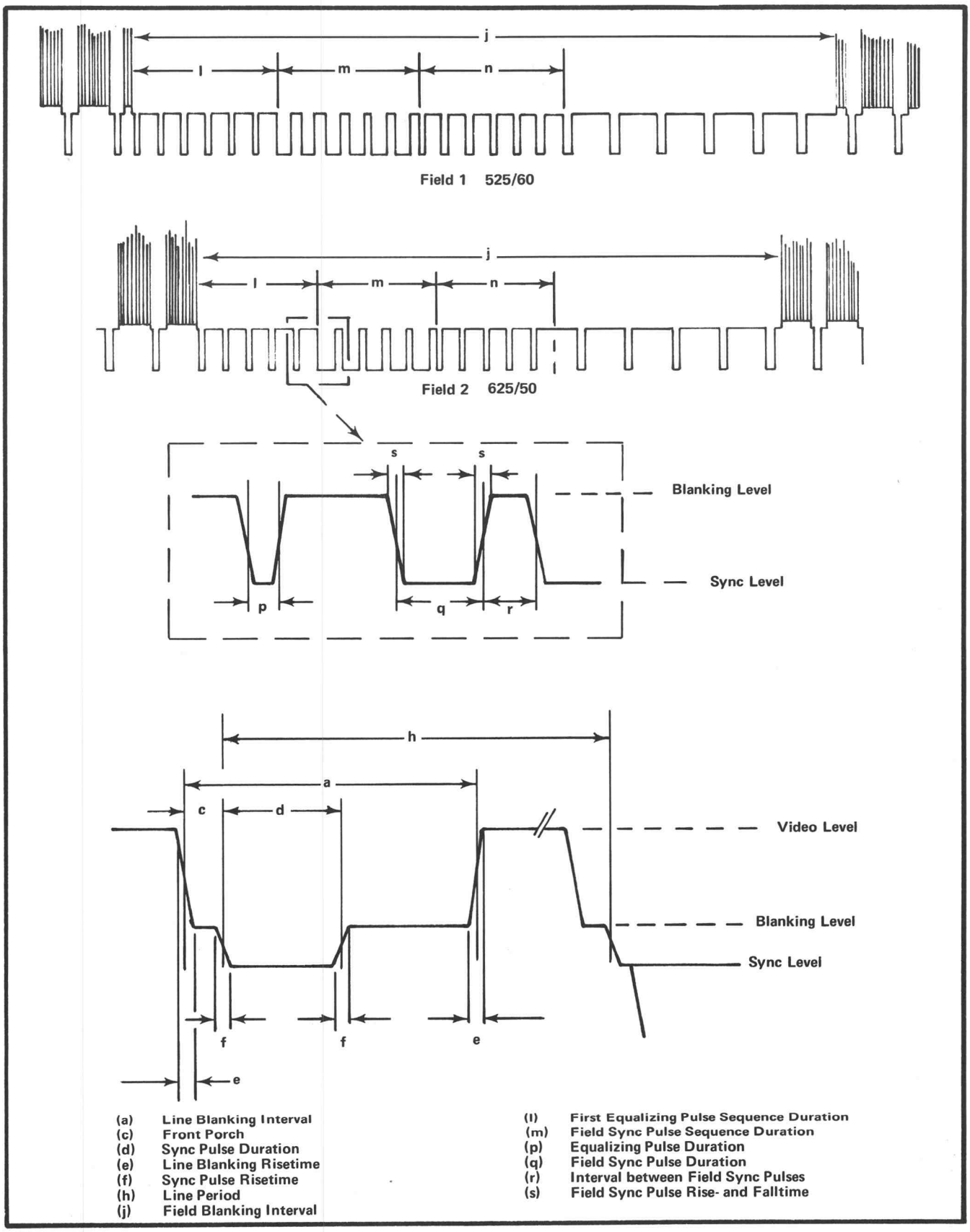
Characteristic	Performance Requirement
Common Mode Rejection Ratio	At least 500:1 at 10 kHz At least 100:1 at 1 MHz At least 10:1 at 5 MHz
Risetime	75 ns or less with 1 V input step
Aberrations	Within 5% of pulse amplitude
Bandwidth	At least 5 MHz with 1 V input
Input Resistance	1 MΩ within 2%
Input Capacitance	40 pF to 50 pF

CRT

Characteristic	Performance Requirement
Dot Writing Time (Stored)	8 µs or less
Stored Resolution	
Vertical	Equivalent to 100 line pairs (closely spaced line pairs exceed 25% incremental storage). Tested using a 100 X 125 dot matrix.
Horizontal	Equivalent to 125 line pairs (closely spaced line pairs exceed 25% incremental storage). Tested using a 100 X 125 dot matrix.
Maximum Incremental Stored Area	25% (100 X 125 dot matrix)
Storage Time	Recommended storage time: 15 minutes or less for specified resolution. Storage time may be extended up to one hour without permanent damage to the target. If a residual image is retained after exteded storage time, it may be removed by successive erasure.

VIDEO

Characteristic	Performance Requirement	
	525/60	625/50
Line Sync Signal	(see Fig. 1-2)	
Pulse Duration	4.8 µs within 0.25 µs	4.8 µs within 0.25 µs
Rise and Fall times	190 ns or less	190 ns or less
	525/60	625/50
Front Porch Duration	1.5 µs within 0.1 µs	1.5 µs within 0.1 µs



(a) Line Blanking Interval
(c) Front Porch
(d) Sync Pulse Duration
(e) Line Blanking Risetime
(f) Sync Pulse Risetime
(h) Line Period
(j) Field Blanking Interval
(l) First Equalizing Pulse Sequence Duration
(m) Field Sync Pulse Sequence Duration
(p) Equalizing Pulse Duration
(q) Field Sync Pulse Duration
(r) Interval between Field Sync Pulses
(s) Field Sync Pulse Rise- and Falltime

Fig. 1-2. Field and line sync signals.

Characteristic	Performance Requirement	
Line Period	63.492 µs[2] (H)	64.000 µs[2] (H)
Field Sync Signal	(see Fig. 1-2)	
Pulse Duration	26.4 µs to 28 µs	26.4 µs to 28 µs
Rise and Fall times	250 ns or less	250 ns or less
Interval Between Field Sync Pulses	4.5 µs within 0.5 µs	4.5 µs within 0.5 µs
Field Sync Pulse Sequence Duration	3H[2]	2.5H[2]
First and Second Equalizing Pulse Sequence Duration	3H[2]	2.5H[2]
Equalizing Pulse Duration	2.27 µs within 0.1 µs	2.27 µs within 0.1 µs
Field Period	16.667 ms[2]	20.000 ms[2]
COMPOSITE SYNC OUT		
Amplitude	4 V P-P within 0.2 V into 75 Ω (negative-going)	
Return Loss	At least 30 dB, 50 Hz to 5 MHz	
COMPOSITE BLANKING OUT		
Amplitude	4 V P-P within 0.2 V into 75 Ω (negative going)	
Return Loss	At least 30 dB, 50 Hz to 5 MHz	
Duration		
H Blanking	10.9 µs within 0.4 µs	
V Blanking	1269 µs, (525/60)[2]; 1260 µs (625/50)[2]	
Rise and Falltimes	190 ns or less	

[2]Digitally determined from 31.5 kHz or 31.25 kHz (within 0.12%) clock.

Characteristic	Performance Requirement
MODULATED RF OUT	
Amplitude	At least 10 mV P-P into 75 Ω
Carrier Frequency	Set to 61.25 MHz within 50 kHz (U.S. TV channel 3). Internally adjustable from 55.25 MHz (U.S. TV channel 2) to 67.25 MHz (U.S. TV channel 4)
Frequency Stability	Within 250 kHz of carrier frequency over +20°C to +30°C range
COMPOSITE VIDEO OUTPUT	
Amplitude Levels	
Sync	300 mV +30 mV, -40 mV from blanking level
Video	
Light Background	Stored level 30 mV to 150 mV above blanking level Un-stored level 600 mV to 800 mV above blanking level
Dark Background	Stored level 600 mV to 800 mV above blanking level Un-stored level 30 mV to 150 mV above blanking level
Output Video Resolution	All dots of 100 X 125 dot matrix shall be discernible (Display monitor adjusted for 1 V P-P video signal)
Video Frequency Response	The difference in video output level between the narrowest vertical stored line and the average level of a 0.5 cm vertical stored line (center screen) will not be more than 50%
Linearity	
Horizontal	1%; vertical lines separated by equal voltage on the Type 4501 X axis will be equidistant within 1% on the video output (center 90% of screen)
Vertical	1%; horizontal lines separated by equal voltages on the Type 4501 Y axis will be equidistant within 1% on the video output (center 90% of screen)
Return Loss	At least 26 dB, 50 Hz to 5 MHz

Characteristic	Performance Requirement
COMPOSITE SYNC IN	Loop-through input
Amplitude	3.5 to 4.5 V (maximum)
Return Loss	At least 30 dB, 50 Hz to 5 MHz
COMPOSITE BLANKING IN	Loop-through input
Amplitude	3.5 to 4.5 V (maximum)
Return Loss	At least 30 dB, 50 Hz to 5 MHz
EXT VIDEO INPUTS	
Amplitude	Recommended input, 1 V P-P into 75 Ω (700 mV of video and 300 mV of sync)
Input Impedance	75 Ω
Return Loss	At least 30 dB, 50 Hz to 50 MHz

REMOTE PROGRAM CONNECTOR, J1304[3]

Characteristic	Performance Requirement
Outputs	
Erase Interval (pin 24)	
Normal Level	+10 V, sourcing 0.1 mA max
During Erase Interval	Level drops to +0.8 V ±0.3 V, sourcing[4] 10 mA maximum, beginning about 10 ms before actual erase cycle starts and holding throughout erase, and ending in coincidence with end of erase cycle. (See Fig. 1-3.)
Read-Write Switching Signal (pin 1)	
READ Mode	+12.75 V within 1 V, sourcing 0.1 mA max.
WRITE Mode	−5 V within 0.5 V, sourcing 10 mA max.
Horiz. Ramp (pin 3)	1 V P-P within 5%, sourcing 5 mA maximum passing through 0 V. Duration is one horizontal line.
Horiz. Drive (pin 20)	5.6 V P-P within 10%, sourcing 4 mA maximum. 0 V or negative, sourcing 0.1 mA maximum for 6 μs ±0.5 μs
Vert. Ramp (pin 7)	0.75 V P-P within 5%, sourcing 5 mA maximum passing through 0 V. Duration is one vertical scan.
Vert. Drive (pin 5)	5.6 V P-P within 10%, sourcing 4 mA maximum.
EIA 525/60	0 V or negative, sourcing 0.1 mA maximum for 571 μs.
CCIR 625/50	0 V or negative, sourcing 0.1 mA maximum for 480 μs.
+15 V (pin 29)	100 mA maximum external load.
+3.75 V (pin 30)	100 mA maximum external load.
−15 V (pin 33)	100 mA maximum external load.
Inputs	
Horiz Ramp (pin 22)	1 V P-P maximum, passing through 0 V, into 1 kΩ.
Vert. Ramp (pin 26)	0.75 V P-P maximum, passing through 0 V, into 1 kΩ.
Read Level (pin 28)	−1.0 V to +1.0 V maximum into 1 kΩ.
Marker (pin 11)	−1 V peak, within read time, for maximum video out. Must not be coincident with Horiz. blanking. Input Z is 51 Ω.
Flyback Write Intensity (pin 9)	+0.1 V maximum during Horiz. blanking and Read Only mode.

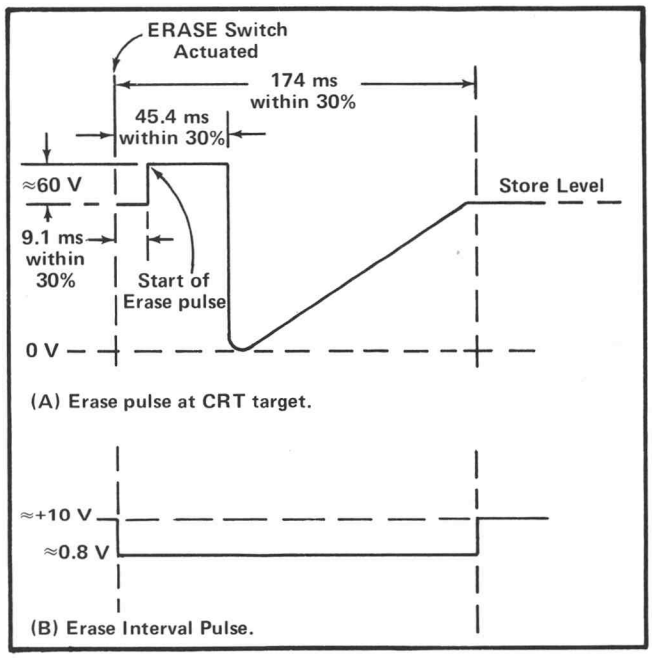


Fig. 1-3. Erase Waveforms.

[3] Remote Program Connectors J1302 and J1304 are shown in Fig. 2-5.

[4] The term "sourcing" refers to the amount of current which can be supplied by the Type 4501 for a particular output voltage.

REMOTE PROGRAM CONNECTOR, J1304[3] (cont)

Characteristic	Performance Requirement	
Remote Control[5] (Switching Requirements)		
Read-Write Mode	Function On (short-circuit current)	Function Off (open-circuit voltage)
Read Only (pin 16)	Sink[6] at least 1.6 mA	+3.75 V max
Write Only (pin 35)	Sink at least 1.6 mA	+3.75 V max
Background (pin 17)		
Dark	Sink at least 1.6 mA	
Light	+5.4 V max (or open circuit)	
Store/Non-Store (pin 37)		
Store	+15 V max (or open circuit)	
Non-Store	Sink at least 1.5 mA	
	Function On (short-circuit current)	Function Off (open-circuit voltage)
Integrate (pin 36)	Sink at least 1 mA	+3.75 V max
Erase (pin 19)	Sink at least 15 μA (Initial closure discharges 1000 pF capacitor charged to from +5 to +15 V.)	$\geq$5 V to $\leq$15 V
Raster Write (pin 34)	Sink at least 4 mA	+15 V max
Program Ground (pin 18)	Remote program ground, switched through front panel Remote-Local switch.	

REMOTE PROGRAM CONNECTOR, J1302[3]

Characteristic	Performance Requirement
Programmable Input Switching Requirements	Same Requirements given for these lines of connector J1304
Non-Store (J1302 pin 6)	Bridged with J1304, pin 37
Erase (J1302 pin 18)	Bridged with J1304, pin 19
Write Only (J1302 pin 22)	Bridged with J1304, pin 35
Background (J1302 pin 23)	Bridged with J1304, pin 17
Erase Interval Output (J1302 pin 7)	Bridged with J1304, pin 24 (see requirements given for J1304)
Read-Write Switching Output (J1302 pin 11)	Bridged with J1304, pin 1 (see requirements given for J1304)
Ground (J1302 pin 19)	Chassis ground return for external program circuits.

POWER SUPPLY

Characteristic	Performance Requirement
Power Connection	This instrument is provided with a three-wire power cord with a three terminal polarized plug for connection to the power source. The third wire is directly connected to the instrument frame, and is intended to ground the instrument to protect operational personnel, as recommended by national and international safety codes.
Line Voltage (RMS)	
115 V Range	
Lo	90 V to 110 V
M	104 V to 126 V
Hi	112 V to 136 V
230 V Range	
Lo	180 V to 220 V
M	208 V to 252 V
Hi	224 V to 272 V
Crest Factor	At least 1.3
Line Frequency Range	48 Hz to 66 Hz
Power	125 watts maximum at 115 V, 60 Hz
Line Current	1.2 A max
Thermal Cutout	Above 62°C

ENVIRONMENTAL CHARACTERISTICS

The following environmental test limits apply when tested in accordance with the recommended test procedure.

[5] Connections for remote control are shown in Fig. 2-6.

[6] The term "sink" refers to the amount of current required by the Type 4501 in a particular situation.

This instrument will meet the electrical performance requirements given in this section following an environmental test. Complete details on environmental test procedures, including failure criteria, etc., may be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

Characteristic	Information
Temperature	
Non-operating	−40°C to +65°C
Operating	0°C to +50°C
Altitude	
Non-operating	To 50,000 feet
Operating	To 15,000 feet

ACCESSORIES

Standard accessories supplied with this instrument can be found on the last page of the Mechanical Parts List. For additional accessories, see the current Tektronix, Inc. catalog.

NOTES

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

To effectively use the Type 4501, the operation and capabilities of the instrument must be understood. This section begins with a description of the storage tube and its operational characteristics, then describes the operation of the front and rear panel controls and connectors, gives first time and general operating information, and contains a chart outlining the functions of the remote program connector. A glossary of terms applicable to this instrument is found at the beginning of the Circuit Description.

Storage Tubes

A brief discussion of storage tube principles is presented at the beginning of the circuit description. With reasonable care, the storage CRT used in this instrument will provide very satisfactory service. The following precautions will prevent damage, increase tube life and maintain optimum performance.

Use only the intensity level required to write a well-defined display. Excessive beam current can cause either a bright burn condition, or if intense enough, a more serious dark burn condition. Avoid continued use of one target area. This causes differential aging of the storage target and may result in residual images.

Avoid leaving a stored display on the screen longer than required. More than fifteen minutes of viewing time is not recommended. Operation in the ready-to-write (fully erased) state gives longest target life.

Storage tube characteristics change with use more noticeably than characteristics of conventional cathode ray tubes. Operating levels for a new tube should be checked after the first 100 hours of operation. Progressively longer periods between checks may then be set.

Storage Tube Phenomena

The stored display on the Type 4501 and the television monitor display may reveal unusual dark or bright areas which resemble previously written information. These are known as "residual images".

Negative residual image. This appears in the ready-to-write state as a negative image of some previously stored display. It is caused by leaving a stored display on the target over an extended period of time. This type of image usually disappears within a few hours of operation.

Dark burn. This is a spot or line across the screen which has a lower light level than the rest of the target when the target is fully written. If extreme, the dark burn area will not store. Dark burn is caused by the destruction of the storage screen from a high intensity writing beam and is similar to phosphor burn in a conventional CRT.

Generally, non-destructive type images will fade in about the same period of time as was needed to produce them. It is important to use the target area as uniformly as possible to maintain uniformity in writing speed, and of the video signal output.

Operating Voltage

The Type 4501 can be operated from either a 115 volt or a 230 volt nominal line voltage source. The Line Voltage Selector assembly on the rear panel converts the instrument from one operating range to the other. In addition, this assembly changes the primary connections of the power transformer to allow selection of one of three regulating ranges. The assembly also includes the two line fuses. When the instrument is converted from 115 volt to 230 volt nominal operation or vice versa, the assembly connects the fuse corresponding to the line voltage selected, to provide the correct protection for the instrument. Use the following procedure to convert this instrument between nominal line voltages or regulating ranges:

1. Disconnect the instrument from the power source.

2. Loosen the two captive screws which hold the cover onto the voltage selector assembly; then pull to remove the cover.

3. To change nominal line voltage selections, pull the Voltage Selector (see Fig. 2-1) until its pins are free of the sockets, turn the selector 180° and reseat the pins in the desired socket. Change the line cord power plug to match the power source receptacle.

4. To change regulating ranges, pull out the Range Selector switch bar (see Fig. 2-1) until its pins are free of the socket; slide it to the desired position and insert the pins into the socket. Select a range that is centered about the average line voltage to which the instrument is to be connected (see Table 2-1).

TABLE 2-1

Range Selector Switch Position	Regulating Range	
	115 Volts Nominal	230 Volts Nominal
LO	90 to 110 volts	180 to 220 volts
M	104 to 126 volts	208 to 252 volts
HI	112 to 136 volts	224 to 272 volts

5. Re-install the cover and tighten the two captive screws.

6. Before applying power to the instrument, check that the indicating tabs on the switch bars are protruding through the correct holes for the desired nominal line voltage and regulating range.

Operating Temperatures

The Type 4501 can be operated where the ambient air temperature is between 0°C and +50°C. The instrument can be stored in ambient temperatures between −40°C and +65°C. After storage at a temperature beyond the operating limits, allow the chassis to come within the operating limits before power is applied. After storage at temperatures below freezing, as the chassis comes within the operating limits it is possible for moisture to form in the instrument. After applying power, allow sufficient warmup time to completely dry out the instrument.

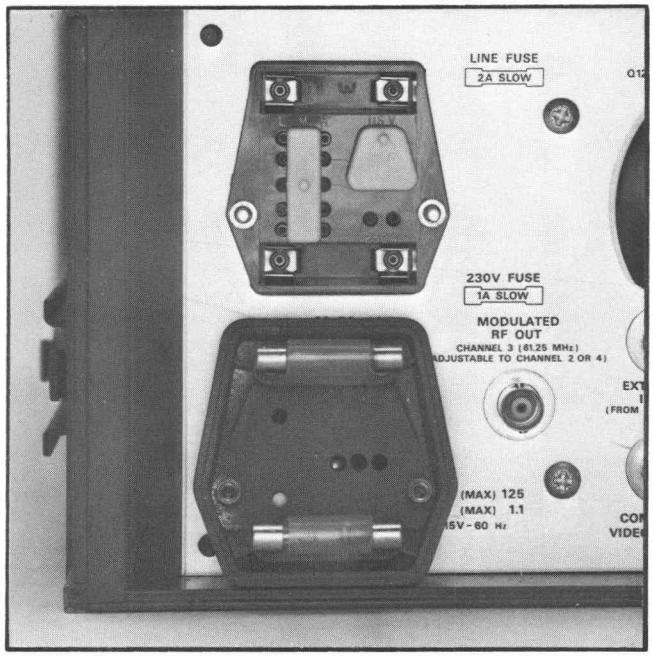


Fig. 2-1. Line Voltage Selector Assembly (shown with cover removed).

A thermal cutout in this instrument provides thermal protection and disconnects the power to the instrument if the internal temperature exceeds a safe operating level. This device will automatically reapply power when the temperature returns to a safe level.

CONTROLS AND CONNECTORS

A brief description of the function or operation of the front and rear panel controls and connectors follows; for their location see Fig. 2-2.

Front panel

POWER ON (toggle switch)	Applies power to the instrument.
Pilot lamp	Indicates when power is on.
INTENSITY	Controls intensity of the writing beam.
POSITION	Positions the writing beam vertically on the CRT.
	Positions the writing beam horizontally on the CRT.

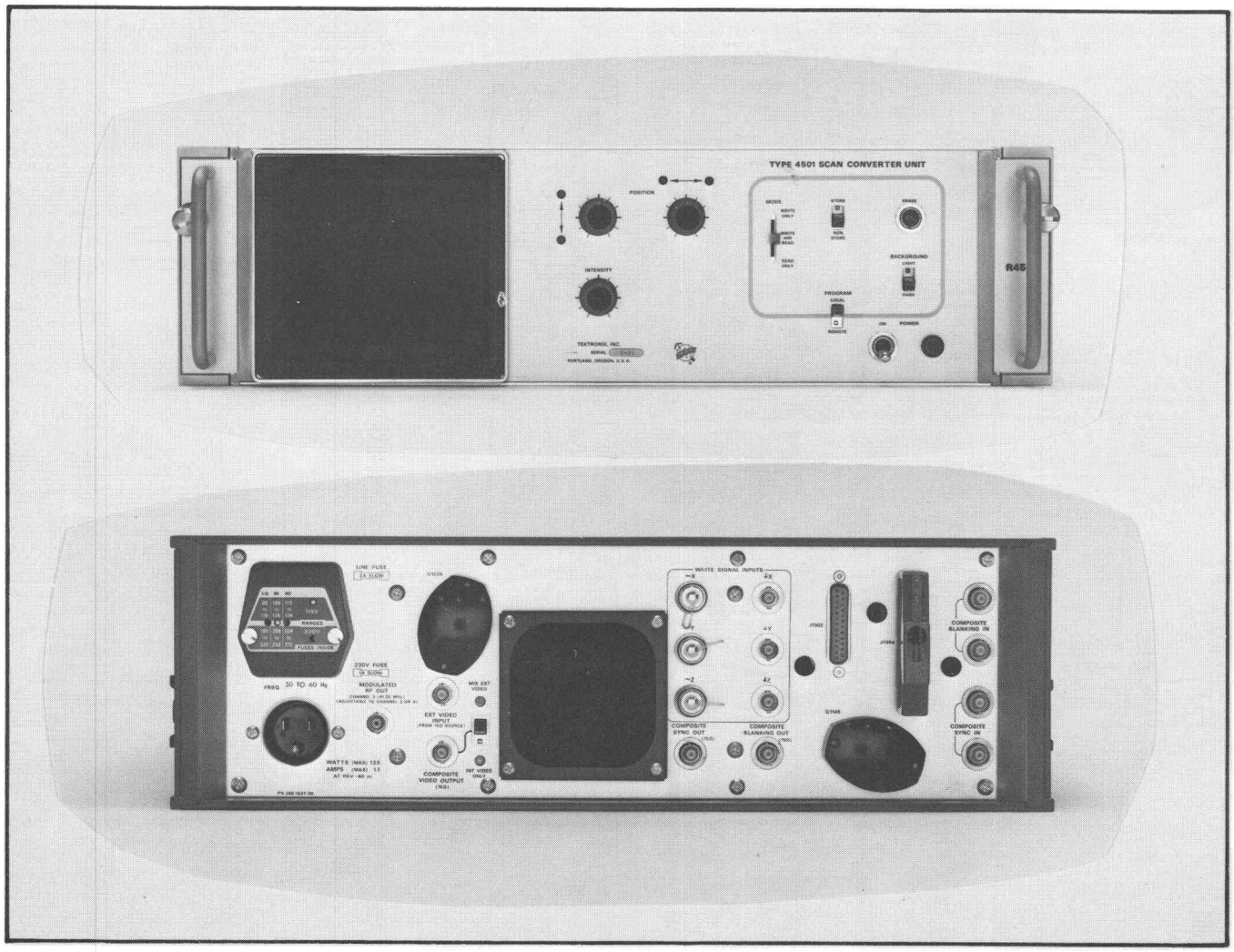


Fig. 2-2. Front and rear-panel controls and connectors.

MODE (three position switch)

WRITE ONLY — In this mode of operation the storage target is not being scanned and the stored information will not be displayed on the monitors. The information can be viewed on the storage CRT.

WRITE AND READ — In this mode of operation the writing beam and scanning ramps are time-shared. The signal is written on the CRT and then scanned to be displayed on monitors.

READ ONLY — The writing beam is disabled in this mode. Any information stored on the CRT is being scanned and can be displayed on monitors.

STORE–NON STORE switch

STORE — Information being written on the CRT will be retained or stored.

NON STORE — The written information will not be retained.

ERASE push-button — Erases any information stored on the storage CRT.

BACKGROUND LIGHT — The background of the video signal on the monitor will be at the white level and the video information will go toward the black level.

DARK — The background of the video signal on the monitor will be at the black level and the video information will go toward the white level.

PROGRAM LOCAL — Allows the following functions to be controlled from the front panel of the Type 4501: Mode, Background, Erase, and Store/Non Store.

REMOTE — This position disables the Local front panel controls and allows them to be controlled from a remote position. The Integrate function, which is not available from a local position, is available from the remote position. See Fig. 2-6.

Rear Panel

Int./Ext Video switch
Mix Ext Video — This switch position allows external video to be coupled into the Type 4501 and mixed with the internal video that is going to the monitor.

The wire strap across C906 (located on the Modulator circuit board) may be removed if it is desired to use AC coupling when in the Mixed Video mode and the external video signal has a DC level which modulates the R.F. output. The removal of this strap must be performed by a qualified technician.

Int. Video Only — This switch position disables the external video in and allows only the internal video to be coupled to the monitor.

Connectors J1302 — Allows the Type 4501 to be compatible with the 601/611. The connector can be disconnected from the Type 601 or 611 and connected directly to J1302.

J1304 — Remote program connector. Refer to Table 2-2 for function of program lines.

Composite Blanking In
Composite Sync In — These connectors allow external television composite sync and composite blanking to be coupled into the Type 4501. The internal generated signals are automatically disabled when external signals are connected.

NOTE

Both composite sync and composite blanking must be coupled into the Type 4501 at the same time, otherwise the internal circuitry will not function correctly.

X Inputs
Y Inputs
Z Inputs — BNC connectors for applying input signals (either single-ended or differential) to the deflection amplifiers (X and Y), and input beam turn-on or turn-off current to the storage CRT through the Z axis amplifier.

Composite Blanking Out
Composite Sync Out — BNC output connectors for composite sync and composite blanking.

Ext Video Input — Input connector which permits external video to be mixed with the internal video and coupled to the monitor.

Composite Video Output — BNC output connector for the composite video signal.

Modulated RF OUT — BNC output connector for the modulated RF video signal.

NOTE

When the RF Modulated output is fed to a TV receiver, the Composite Video output must be terminated in 75 ohms or overmodulation will result.

Line Voltage Selector Assembly — Switching assembly to select the nominal operating voltage and the line voltage range. The assembly also includes the line voltage fuses. (See Operating Voltage, as described previously in this section).

FIRST TIME OPERATION

The Type 4501 is shipped from the factory with the Internal switches in the following positions:

525/60 625/50 switch 525/60
Linear/Limiting ..... limiting

NOTE

The following connector must be connected to J1304 in order for the instrument to operate correctly: ADAPTER, connector, loop through 013-0108-00. See Fig. 2-2.

1. Connect the instrument to a suitable power source.

2. Connect the composite video output connector on the Type 4501 to the television monitor video input. Switch monitor to 75 Ω Video input impedance. Connection may be made using the 25 ft. length of 75 Ω cable (Tektronix Part No. 012-0157-00) included as a standard accessory. Accessories are shown in the Mechanical Parts List.

3. Turn the INTENSITY control fully counterclockwise, center the POSITION controls, place the MODE switch in the WRITE AND READ position, STORE/NON STORE switch to the STORE position, and the PROGRAM switch to the LOCAL position.

4. Turn the POWER switch to ON and allow one minute warmup.

5. Push and release the ERASE button to clear the screen of written areas accumulated during warmup. Increase the INTENSITY control until the spot (writing beam) is visible.

NOTE

If the intensity is too low, the Type 4501 will not store and the monitor display will not appear fully written. If the intensity is too high, damage to the CRT phosphor may result.

6. Use the POSITION controls to move the writing beam both horizontally and vertically across the CRT, checking for proper storage and for a display on the monitor.

NOTE

Only the written information that is within the raster area will be displayed on the television monitor. The raster area is 10 cm horizontally and 7.5 cm vertically, and can be recognized visually, in the WRITE AND READ or READ ONLY modes, as the intensified portion of the CRT.

7. Erase the stored display by pressing the ERASE button.

8. Repeat steps 6 and 7 a few times to ensure proper operation.

9. Using the POSITION controls, draw a line along the outside edge on all four sides of the Type 4501 raster. Check the monitor display for a complete rectangle. If the monitor display is not correct, the monitor Height and Width controls will need adjusting. Refer to the instruction manual for the television monitor for these adjustments.

GENERAL OPERATING INFORMATION

General

The Type 4501 is designed to store data (via digital to analog converters) from digital computers and other data transmission systems. The stored or non-stored data that is written on its 5 inch storage tube is scanned by an internally generated television raster and then converted to a composite television signal, both composite video and modulated RF. The television signal can then be conveniently viewed on large screen television monitors or receivers. The video output conforms to EIA, 525 line, 60 field or CCIR, 625 line, 50 field television timing standards. The RF output permits displaying information on U.S. channel 2, 3 or 4 of conventional television receivers. The output from a single scan converter may be looped through a multiple number of monitors for viewing at remote locations.

If the contrast of the video signal on the monitor is unsuitable, first check the monitor for proper operation. Then refer to step 4 of the optional steps in the Type 4501 calibration procedure.

The Focus and Astigmatism controls for this instrument are internal adjustments and the procedure for adjusting them is contained in the Calibration section.

While operating the Type 4501, periodically (150 to 200 hours) place the mode switch in the WRITE ONLY position and observe the storage tube (approximately 2 to 3 minutes) for retention of the written information. If the stored display tends to drop out, the operating level of the storage target probably needs adjusting. This can be accomplished by performing the calibration steps.

Input Requirements

The deflection factor for both the vertical (Y) and horizontal (X) amplifiers is 0.1 V per centimeter. The amplitude of the raster in the vertical plane is 7.5 cm and in the horizontal plane it is 10 cm. If the input signal exceeds 0.75 V along the vertical axis or 1.0 V along the horizontal axis, not all of the signal will be on screen. The maximum input voltage is ±200 volts (DC and peak AC). The X and Y amplifiers both have a common mode dynamic range of 5 volts peak-to-peak sine wave. The + inputs for both the X and Y amplifiers are non-inverting inputs; the – inputs for the amplifiers are inverting inputs. A positive signal on the + input of the X amplifier causes the beam to move from left to right, and a positive signal on the + input of the Y amplifier causes the beam to move up.

The Z Axis amplifier can be operated as either a linear amplifier or a limiting amplifier. The amplifier can be changed to the limiting mode by actuating an internal switch for the + input which is located on the Z Axis Amplifier board (see Fig. 2-3). When the amplifier is operated in the linear mode, the differential capability provides cancellation of common mode signal components. Maximum writing intensity is produced on the CRT with a 1.0 V P-P signal and normal writing intensity is produced with a 0.5 V

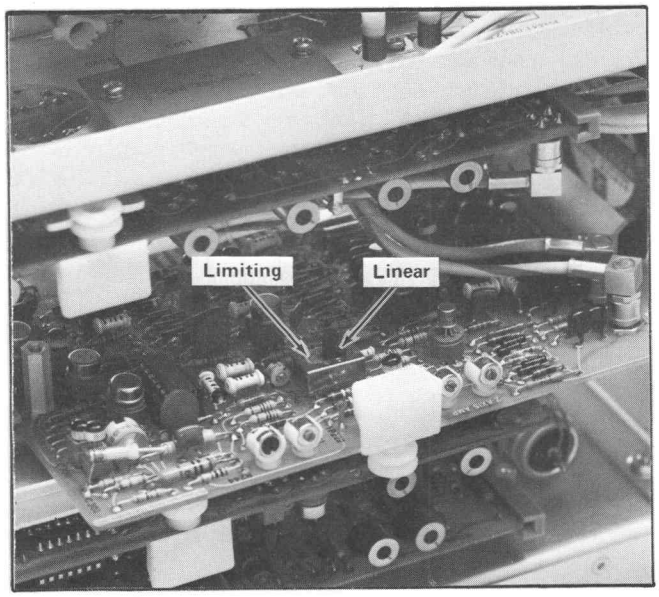


Fig. 2-3. Switch for changing the Z Axis Amplifier to either the linear or limiting mode.

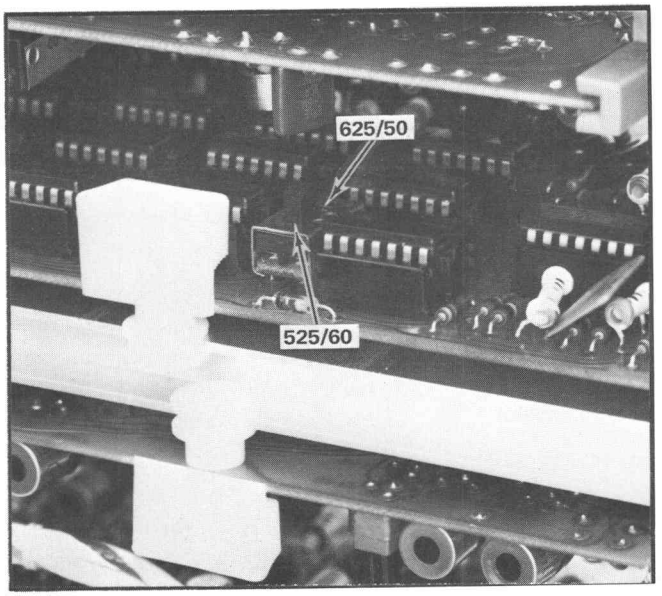


Fig. 2-4. Location of 525/625 line switch.

P-P signal. Usable intensities can be produced with smaller amplitude signals by using a minimum setting with the INTENSITY control and in some cases using the remote Integrate function. In linear operation, the common mode dynamic range is 5 volts peak-to-peak sine wave single ended input signal range is ±1.5 V, and maximum input voltage is ±200 volts (DC and peak AC). A positive signal on the + input increases the intensity and a negative signal on the – input also increases the intensity.

When the amplifier is operated in the limiting mode, a single ended signal at the + input is routed through an amplitude limiting amplifier. The input signal is automatically limited to 1 V peak-to-peak. In this mode, voltage levels from +1 V to +50 V turn the beam on to a fixed level; this level can be adjusted with the INTENSITY control. Voltage levels from +0.5 V to –50 V turn the beam off. The maximum input voltage in the limiting mode is ±50 volts, (DC and peak AC). The +Z input impedance becomes ≈ 23 kΩ.

525/625 Line Operation

The output sync of the Type 4501 can be selected to conform to 525 line, 60 field television standards or to 625 line, 50 field television standards. This is accomplished by an internal switch (see Fig. 2-4) located on the Read Raster circuit board. Placing the 525/625 switch in the desired position is the only requirement in the operation of the Type 4501, to select either 525 line or 625 line operation.

Graticule

The CRT graticule is primarily used for calibration purposes only. The graticule is inscribed with a dashed line to indicate the 7.5 cm area, both vertically and horizontally. The solid line (approximately 0.5 inch in length) indicates the 3 dB point when checking the vertical and horizontal bandwidth.

REMOTE PROGRAM CONNECTOR INFORMATION

General

The rear panel remote program connectors J1302 and J1304, have other uses in addition to providing for the connection of a remote programmer (see Fig. 2-5). J1304 provides for connection of all the remote program functions, horizontal and vertical input and output ramps, supply voltage outputs, and other inputs and outputs. Table 2-2 lists the function of the pins of connector J1304.

Pins of connector J1302 provide for connection of X, Y, and Z inputs, some remote programming functions, output signals, and some reserved functions. Table 2-3 lists the functions of the pins of connector J1302.

J1302 makes the Type 4501 compatible with the Type 601 and Type 611 Display Units (and the T4002 Graphic Display Unit and 4601 Hard Copy Unit). The cable

TABLE 2-2

Remote Program Connector J1304

Pin No.	Function	Remarks
1	Switching Signal Out	This signal indicates Read and Write states. Read level ≈+7.5 V; Write level ≈−5 V.
3	Horiz. Ramp Out	Pin 3 is normally strapped to pin 22 (Horiz. Ramp In), through the Adapter shown in Fig. 2-2. If this strap is removed, the Horiz. Ramp Out is not coupled to the input of the Amplifier. Ramp Amplitude 1 V P-P.
5	Vert. Drive Out	This pulse occurs at the television field rate and during the vertical interval time.
7	Vert. Ramp Out	Pin 7 is normally strapped to pin 26 (Vert. Ramp In) through the adapter shown in Fig. 2-2. If this strap is removed, the Vert. Ramp Out is not coupled to the input of the Y Amplifier. Ramp Amplitude 0.75 V P-P.
9	Flyback Write Intensity Input	+0.1 V maximum (permitted only during horizontal blanking interval and while in Read Only mode).
11	Marker Input	−1 V Pulse (referenced to gnd.) into 50 Ω. Used for Cursor; i.e., Light pen used to designate a point on the display.
16	Read Only	Selectable with program ground (Fig. 2-6).
17	Background	Selectable with program ground (Fig. 2-6).
18	Program Ground	See Fig. 2-6.
19	Erase	Selectable with program ground (Fig. 2-6).
20	Horiz. Drive Out	Pulse occurs at the television line rate.
22	Horiz Ramp Input	See remarks for pin 3.
24	Erase Interval Out	Negative-going pulse of the same time duration as the erase cycle. Used to notify auxiliary equipment that the Type 4501 is being erased.
26	Vert. Ramp Input	See remarks for pin 7.
27	Flyback Write Gnd.	
28	Read Level Input	Pin 28 is normally strapped to ground (pin 27): This strap must be in place for normal operation of the Type 4501. (See discussion under Applications.)
29	+15 V Output	100 mA maximum to an external load.
30	+3.75 V Output	100 mA maximum to an external load.
33	−15 V Output	100 mA maximum to an external load.
34	Raster Write (Programmable only. Fig. 2-6)	Permits a high contrast signal from a television camera to be coupled into the Z Axis amplifier and written on the CRT by the television raster generated in the Type 4501. In the Raster Write mode the Z Axis Amplifier is switched to the write mode and the X/Y Amplifiers are operating in the read mode.
35	Write Only	Selectable with program ground (Fig. 2-6).
36	Integrate	Selectable with program ground (Fig. 2-6).
37	Non-Store	Selectable with program ground (Fig. 2-6).

Pins 2, 4, 6, 8, 21, 23, and 25 are connected to ground. The pins not mentioned in this table are not used. The feed-thru adapter, shown connected to J1304 in Fig. 2-2, connects pin 3 to pin 22 and pin 7 to pin 26.

TABLE 2-3

Remote Program Connector J1302

Pin No.	Function	Remarks
1	+X Input	0.1 V/cm deflection
2	−X Input	0.1 V/cm deflection
3	Y Ground	Chassis ground
4	+Z Input	0.5 V to 1 V (Refer to Input Requirements under General Operating Information, this section)
5	−Z Input	0.5 V to 1 V
6	Non-Store	Selectable with program ground (Fig. 2-6)
7	Erase Interval Out	A negative-going pulse of the same timy duration as the erase cycle that can be used to notify auxiliary equipment that the Type 4501 is being erased.
9	*Intensity 3	
11	Switching Signal Output	Signal indicates Read and Write states: Read level ≈+7.5 V; Write level ≈−5 V
12	*Target Shield	
13	*Target	
14	X Ground	Chassis ground
15	+Y Input	0.1 V/cm deflection. 0.75 V gives full scale deflection.
16	−Y Input	0.1 V/cm deflection. 0.75 V gives full scale deflection.
17	Z Ground	Chassis ground
18	Erase	Selectable with program ground (Fig. 2-6)
19	Ground	Chassis ground.
22	Write Only	Selectable with program ground (Fig. 2-6).
23	Background	Selectable with program ground (Fig. 2-6).
25	*Target	

Pins not mentioned in this table are not used.

* No wiring to pins designated, but pins are reserved for use indicated (see discussion under applications).

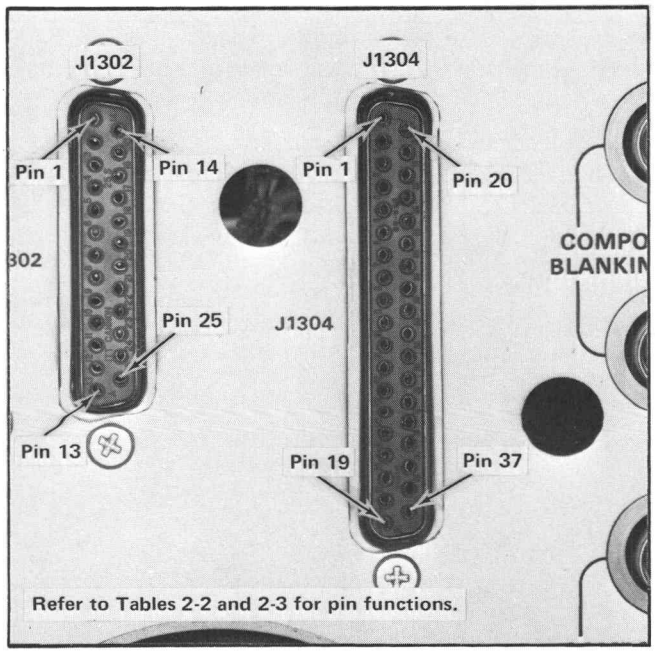


Fig. 2-5. Remote program connectors J1302 and J1304.

supplying X, Y, and Z signal inputs and remote programming information to the Display unit can be disconnected, at the Display unit, and connected into J1302 on the Type 4501.

An Interconnecting cable can be used to connect J1302 on the Type 4501 to the input connector (same type as J1302) of the Type 601 or Type 611 Display Unit. With this connection, signals applied to the X, Y, and Z (BNC) input connectors, on the rear panel of the Type 4501, are fed to the corresponding amplifiers in the Display Unit and Scan Converter. This will provide a display on both units. One of the X, Y, and Z inputs of some devices, such as the Type 601 and Type 611 Display Units, is connected to the instruments chassis. Connection of such instruments to J1302 will ground the −X, −Y, and −Z (BNC) connectors of the Type 4501 rear panel. Input signals will therefore be sent to the Type 4501 input amplifiers single-ended. Input capacitance and resistance, at the X, Y, and Z (BNC) input connectors of the Type 4501, will be affected when the Display Unit is connected to J1302.

Four of the programming pins of J1304 are connected to programming pins of J1302. Therefore, some program-

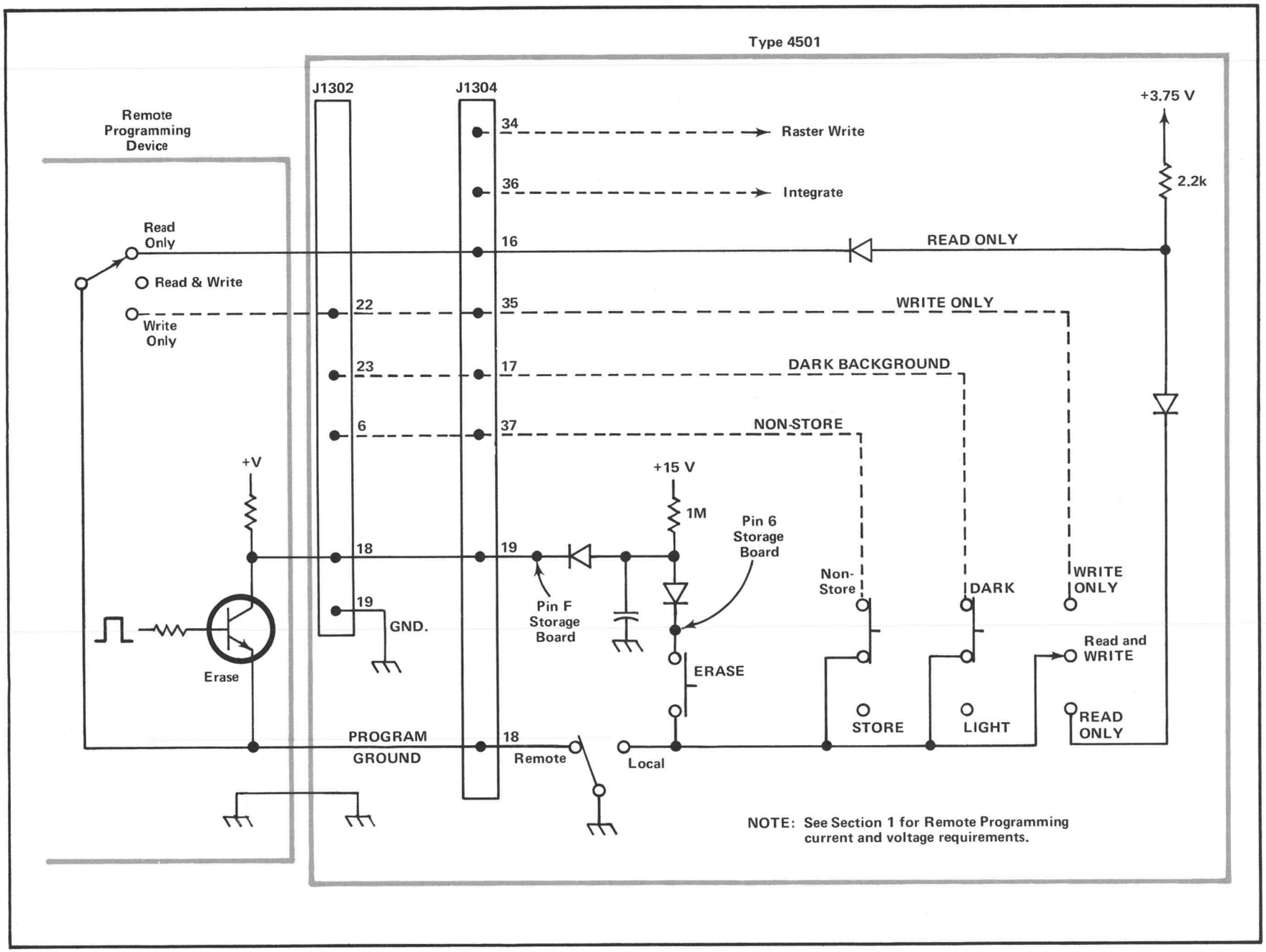


Fig. 2-6. Connection of Remote Program switches.

ming information delivered to J1304 also appears on J1302. Programming information on pins of J1302, to which the Type 601 or Type 611 Display Unit can respond, affects both the Display Unit and Scan Converter. With a Display Unit connected to J1302, the effect on remote programmer requirements must also be considered. For example if Non-Store is remotely programmed, the programming device must be able to simultaneously satisfy the Non-Store programming requirements of both the Scan Converter and the Display Unit. See Section 1 for Specifications.

Reserved Leads of J1302

Four of the pins of J1302 (pins 9, 12, 13, and 25) are shown reserved in Table 2-3. No wires are connected to these pins except for instruments ordered with a modification adapting the Type 4501 for use with the 4601 Hard Copy Unit. This modification permits a display stored on the Type 4501 Scan Converter to be reproduced by the 4601 Hard Copy Unit. Consult your local Tektronix, Inc. Field Office or Field Engineer for further information about this modification.

Common Output Signals of J1302 and J1304

Two output signals of the Type 4501 are available at both J1302 and J1304 as shown by Table 2-2 and Table 2-3. The Erase Interval pulse is available at pin 7 of J1302 and at pin 24 of J1304. The Read-Write Switching Signal is available at pin 11 of J1302 and at pin 1 of J1304.

Remote Programming Using J1302 and/or J1304

Fig. 2-6 illustrates two methods of remote programming the Type 4501 (the pins of the remote program connector that are used are also shown). One method uses switches similar to the ones on the Type 4501 front panel. The other method uses a transistor that is switched ON by a change in level at its base. Either of these methods or other methods of remote programming may be used. See Section 1 for remote programming device requirements.

Four program lines, shown in Fig. 2-6, (Erase, Non-Store, Dark Background, and Write Only) go to J1302, J1304, and the 4501 front panel switches. For simplification, isolation diodes, programming current source, and the circuit affected are not shown for the program lines that are represented by dashed lines.

It should be noted that Read Only may be selected remotely using J1304, or Locally using the front panel switch but not at J1302. Two other functions (Raster Write and Integrate) may be selected only by using J1304.

When one side of the switching device, in the remote programmer, is connected to Program Ground (pin 18 of J1304) in Fig. 2-6, remote programming of the Type 4501 and a Display Unit connected to J1302 is possible only with the Type 4501 LOCAL-REMOTE switch in the REMOTE position.

When either pin 19 of J1302 or the chassis of the programming device is used instead of pin 18 of J1304, remote programming is effective with the Type 4501 PROGRAM switch in either LOCAL or REMOTE position. Front panel controls of the Type 4501 are effective only in the LOCAL position of the PROGRAM switch. Using pin 19 of J1302 or chassis ground with LOCAL selected, permits erasing from the 4501 front panel or by remote programming. With LOCAL selected, Background and Store/Non-Store state can be remotely programmed only if the 4501 front panel switches are in the STORE and LIGHT positions. If READ ONLY is selected at the Type 4501 front panel with WRITE ONLY by the remote programming device, or vice-versa, the result will be a Write Only command.

Use of Feedthru Adapter for J1304

Pins of connector J1304 shorted by the Feedthru Adapter (shown in Fig. 2-2) appear in Fig. 2-7. When the Adapter is plugged into J1304, pin 3 is connected to pin 22 and pin 7 is connected to pin 26. Unless an external signal source is providing input to pins 22 and 26, the shorting straps provided by the Adapter are needed to provide the X and Y ramps required for reading.

The Adapter may be wired and used as the connector at one end of an interconnecting cable between J1304 and a remote programming unit or other device. Unless external ramps are applied to pins 22 and 26 of J1304 the shorting straps between pins 3 and 22, and pins 7 and 26 must be left in place. Use of external ramps is discussed in this section under the heading of Basic Applications.

External Inputs Affecting CRT Beam Current

Two external inputs are provided at J1304 to permit changing the CRT beam current at certain times in a TV

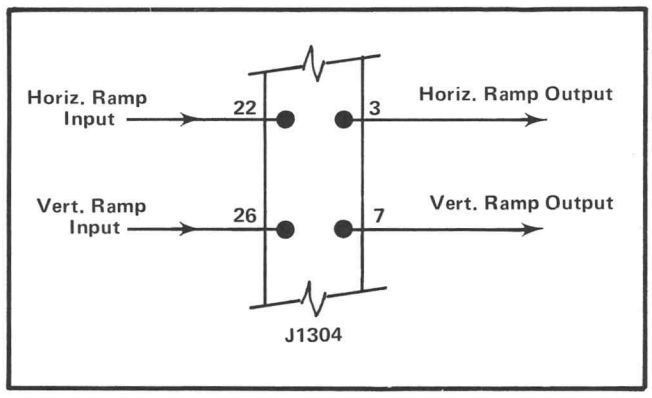


Fig. 2-7. Pins shorted by the Feedthru Adapter.

horizontal scan time. Through one input, Read Level In (J1304-28), a DC voltage may be added to the control amplifier error signal to change the read current. This might be necessary when externally windowing or "zooming" the scan down to cover small portions of the target area. Concentration of normal read current on a small target area will cause that area of the target to write (fade positive).

The other external input is, Flyback Write Intensity (J1304-9). The term refers to the time in a horizontal TV scan line when blanking and sync are present (Refer to Fig. 2-8). In the Type 4501 it is the time between blanking ears when the writing beam is in the Write-Read mode. In this mode, instead of switching to the Write input signals, the X, Y, and Z amplifier may be left in the Read Only mode. If signals are communicated to these amplifiers through the ramp inputs and Flyback Write Intensity input only during the space between blanking ears, the spot can be directed as in the Write-Read mode without interfering with the Read video. In this manner it is possible to inject a second set of

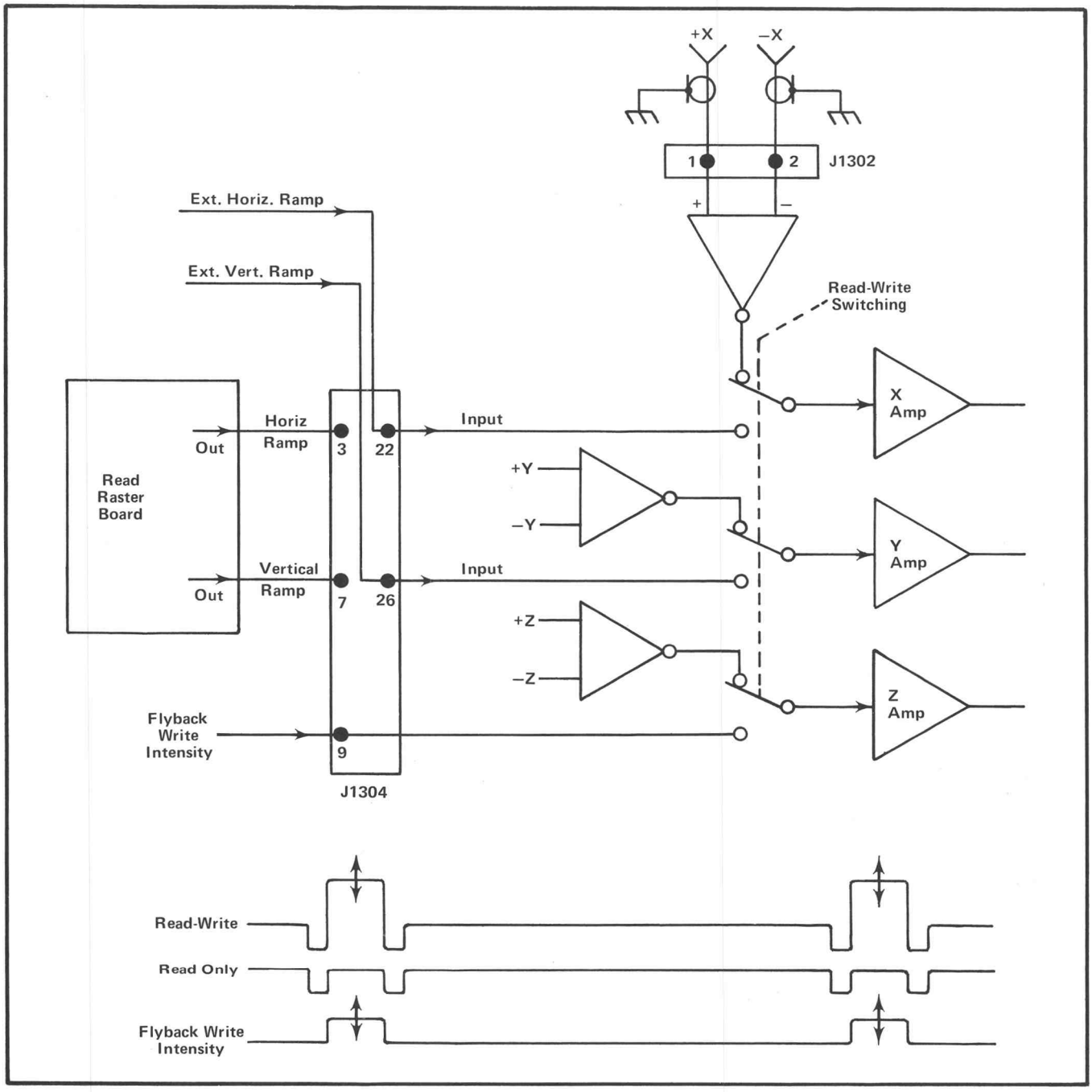


Fig. 2-8. Read-Write Switching Block Diagram.

write inputs without disconnecting the normal write input signals. Flyback Write Intensity signals must be accurately gated into the time slot between blanking ears to avoid interference with the picture video.

Connector Compatibility

The Type 4501 uses a 25 pin connector for J1302 to provide interconnection of the Type 4501 and other Tektronix Display Devices. Instruments having the same type connector as J1302 are listed at the head of the columns of Table 2-4. This table lists the connector number and the function assigned to the connector pins according to instrument type. Many useful instrument combinations result from this connector compatibility.

BASIC APPLICATIONS

The following information describes the procedures and techniques for utilizing the Type 4501 in a few basic applications. These applications are not described in detail as each individuals requirements can vary. Familiarity with the Type 4501 will permit these basic applications to be applied to a wide variety of uses. See information given in this Section under the heading of "REMOTE PROGRAM CONNECTOR INFORMATION".

Computer Graphics

The Type 4501 is capable of storing up to 600 nominal alphanumeric characters. These characters are then scan-converted and legibly displayed on a television monitor.

TABLE 2-4

CONNECTOR COMPATIBILITY

	601	611	T4002	
	J199	J340	J251	J340
1	+X INPUT	+X INPUT	X OUTPUT	X INPUT
2	X GROUND	X GROUND	X GROUND	X GROUND
3	Y GROUND	Y GROUND	Y GROUND	Y GROUND
4	+Z INPUT	+Z INPUT	Z OUTPUT	Z INPUT
5	Z GROUND	Z GROUND	Z GROUND	Z GROUND
6	NON-STORE	NON-STORE	———	———
7	ERASE INTERVAL	ERASE INTERVAL	ERASE INTERVAL	ERASE INTERVAL
8	———	WRITE THROUGH	INTENSITY 2	INTENSITY 2
9	INTENSITY 3	INTENSITY 3	———	INTENSITY 3
10	———	———	PRINT BUSY	———
11	———	———	———	———
12	TARGET SHIELD	TARGET SHIELD	———	TARGET SHIELD
13	TARGET	TARGET	———	TARGET
14	X GROUND	X GROUND	X GROUND	X GROUND
15	+Y INPUT	+Y INPUT	Y OUTPUT	Y INPUT
16	Y GROUND	Y GROUND	Y GROUND	Y GROUND
17	Z GROUND	Z GROUND	Z GROUND	Z GROUND
18	ERASE	ERASE	ERASE	ERASE
19	PROGRAM GROUND	PROGRAM GROUND	PROGRAM GROUND	PROGRAM GROUND
20	———	VIEW	VIEW	VIEW
21	———	———	SEND	———
22	———	———	———	———
23	———	———	———	———
24	———	———	REMOTE COPY	———
25	TARGET	TARGET		TARGET

The signals required for the scan converter are an analog voltage, from the digital to analog converters of the computer, coupled into the X and Y amplifiers of the Type 4501; and a blanking/unblanking pulse from the computer coupled into the Z Axis amplifier. An Erase Interval pulse is available at pin 24 of J1304 that can be coupled to the computer to notify it that the scan converter is being erased.

Oscilloscope Displays

The storage capability of the Type 4501 permits convenient viewing of single-event or low repetition rate information. The information is stored on the Type 4501 and then converted to a television signal and displayed on a large screen television monitor.

This application requires that a 1 V ramp be coupled into the X amplifier and a blanking signal, that is concurrent with the ramp, coupled into the Z Axis amplifier. The signal to be viewed is coupled into the Y amplifier.

Television Camera Video Tape Signals

This type of application can be adapted to many uses. The signal (high contrast) from the television camera or video tape is fed directly into the Type 4501 through the Z Axis amplifier. The Type 4501 is programmed to operate in the Raster Write mode of operation. This is accomplished by applying program ground to Pin 34 of J1304, the Remote Program Connector. The Type 4501 must be synchronized with the signal source by either supplying or receiving separate composite sync and composite blanking. In this mode of operation, the signal is written on the storage CRT as a two state image by the television raster that is generated in the Type 4501. The composite sync and composite blanking signals are combined with the video signal in the Type 4501 and the signal to the monitor is a composite video (or modulated RF) signal.

TABLE 2-4 (cont)

CONNECTOR COMPATIBILITY

	T4005		4501	4601	
	J101, 2, 3, 4	J340	J1302	J700	J705
1	+X OUTPUT	+X INPUT	+X INPUT	X OUTPUT	X INPUT
2	–X OUTPUT	–X INPUT	–X INPUT	X GROUND	X GROUND
3	Y GROUND	Y GROUND	Y GROUND	Y GROUND	Y GROUND
4	+Z OUTPUT	+Z INPUT	+Z INPUT	Z OUTPUT	Z INPUT
5	–Z OUTPUT	–Z INPUT	–Z INPUT	Z GROUND	Z GROUND
6	NON-STORE	NON-STORE	NON-STORE	— INTERNAL CONNECTION —	
7	ERASE INTERVAL	ERASE INTERVAL	ERASE INTERVAL	— INTERNAL CONNECTION —	
8	INTENSITY 2	INTENSITY 2	———	— INTERNAL CONNECTION —	
9	———	INTENSITY 3	INTENSITY 3	GROUND CLOSURE	———
10	———	———	———	COPY GATE	———
11	———	———	SWITCHING SIGNAL	———	———
12	———	TARGET SHIELD	TARGET SHIELD	TARGET SHIELD	———
13	———	TARGET	TARGET	TARGET	———
14	X GROUND	X GROUND	X GROUND	X GROUND	X GROUND
15	+Y OUTPUT	+Y INPUT	+Y INPUT	Y OUTPUT	Y INPUT
16	–Y OUTPUT	–Y INPUT	–Y INPUT	Y GROUND	Y GROUND
17	Z GROUND	Z GROUND	Z GROUND	Z GROUND	Z GROUND
18	ERASE	ERASE	ERASE	ERASE INTERRUPT	ERASE INTERRUPT
19	PROGRAM GROUND	PROGRAM GROUND	CHASSIS GROUND	— INTERNAL CONNECTION —	
20	VIEW	VIEW	———	— INTERNAL CONNECTION —	
21	———	———	———	— INTERNAL CONNECTION —	
22	WRITE ONLY	WRITE ONLY	WRITE ONLY	— INTERNAL CONNECTION —	
23	———	———	BACKGROUND	— INTERNAL CONNECTION —	
24	———	———	———	———	REMOTE COPY
25	———	TARGET	TARGET	TARGET	———

NOTES

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section of the manual contains a description of the circuitry used in the Type 4501. The description begins with a discussion of the basic storage tube operating principles as used in this instrument. This is followed by a block diagram description to aid in understanding the overall function of the Type 4501 circuitry. Then each circuit is described in detail. Conventional current flow (positive to negative) is used in this circuit description.

GLOSSARY OF TERMS AND STORAGE TUBE NOMENCLATURE

Television Terms

H RATE: The time for scanning one complete horizontal line, including trace and retrace, (63.5 μs).

COMPOSITE SYNC: The composite sync signal does not contain either video information or blanking signals. The signal is made up of two basic pieces of information, which are:

1. line sync—Line sync pulses occur at 15.750 kHz repetition rate to synchronize the horizontal scanning line termination in both the camera and the receiver.

2. field sync—Field sync pulses occur at the beginning of each scanning field at a 60 Hz rate to synchronize the camera and receiver field scanning. The field sync pulse is serrated to simultaneously provide line sync information during the occurrence of the field sync pulse.

COMPOSITE BLANKING: The composite blanking signal contains both the horizontal and vertical blanking pulses. The instantaneous amplitude of the pulses blanks the CRT during horizontal and vertical retrace.

COMPOSITE VIDEO: The complete video signal. For monochrome, it consists of the picture signal and the blanking and synchronizing signals. For color, additional color synchronizing signals and color picture information are added.

EQUALIZING PULSES: Pulses of one half the width of the horizontal sync pulses, which are transmitted at twice the rate of the horizontal sync pulses, during the blanking intervals immediately preceding and following the vertical sync pulses. The action of these pulses causes the vertical deflection to start at the same time in each interval, and also serves to keep the horizontal sweep circuits in step during the vertical blanking intervals immediately preceding and following the vertical sync pulse.

FIELD: One half of a complete picture (or frame) interval, containing all of the odd or even scanning lines of the picture.

FRONT PORCH: That portion of the composite picture signal which lies between the leading edge of the horizontal blanking pulse and the leading edge of the corresponding sync pulse.

HORIZONTAL BLANKING: The blanking signal at the end of each scanning line.

SERRATED PULSES: A series of equally spaced pulses within a pulse signal. For example, the vertical sync pulse is serrated in order to keep the horizontal sweep circuits in step during the vertical sync pulse interval.

VERTICAL BLANKING: Refers to the blanking signals which occur at the end of each field.

General Terms

AMPLIFIER, X AXIS: Used interchangeably with Horizontal Amplifier; the amplifier for signals intended to produce horizontal deflection.

AMPLIFIER, Y AXIS: Used interchangeably with Vertical Amplifier; the amplifier for signals intended to produce vertical deflection.

AMPLIFIER, Z AXIS: The amplifier for signals intended to turn on and turn off the CRT beam current.

Storage Terms

BACKGROUND LUMINANCE: The luminance of the stored target when it is completely erased and at a specified operating voltage.

COLLIMATION LENS: An electrostatic lens used to adjust the trajectories of flood gun electrons.

COLLIMATION ELECTRODE: An element used in the collimation lens.

CONTRAST RATIO: The ratio of stored luminance to background luminance at a given operating voltage.

CONVENTIONAL MODE: That mode of operating a storage tube where the display does not store, but performs with the usual phosphor luminance and decay.

ERASE: To momentarily change electrode potentials in such a manner that previously stored information is removed (n: Erasure).

ERASE CYCLE: The sequence of potential changes required to erase the storage target and return it to the ready-to-write state.

FACEPLATE: That wall of the cathode ray tube providing the display area.

FADE POSITIVE LEVEL: The highest operating voltage at which stored information can be retained.

FADE UP: In a storage tube the failure of a unwritten area to remain at background brightness. The background spontaneously moves to the stored brightness of the written state.

FLOOD GUN: A low-energy electron gun directing a large cone of electrons toward the entire storage target.

FULLY WRITTEN: The condition under which the entire storage target is in the written state.

INTEGRATE: To interrupt flooding of the storage target and permit the writing gun electrons to sum over several sweeps (n: Integration).

LUMINANCE UNIFORMITY RATIO: The ratio of the luminance of the brightest to the dimmest area on the target when the target is fully written.

NON-STORE LEVEL: The backplate voltage of a storage tube in the conventional mode.

OPERATING LEVEL: The mid-point of the operating range.

OPERATING POINT: The operating voltage (within the operating range) chosen for a given tube performance.

OPERATING RANGE: The voltage range within which information can be written and completely stored under given conditions of operation (upper writing limit minus writing threshold).

OPERATING VOLTAGE (OR STORE LEVEL): The potential difference between the flood gun cathode and the storage target backplate.

READY-TO-WRITE STATE: The stable mode of any area of the storage target after erasure and before writing.

REST POTENTIAL: The equilibrium potential assumed by the unwritten areas of the target when it is operated in the storage mode.

RETENTION THRESHOLD: The lowest operating voltage at which stored information can be retained anywhere within the quality area.

STABLE RANGE: In a storage tube the operating voltage range within which information can be retained (fade positive minus retention threshold).

STORE: To retain the written information on the storage target after the writing beam has passed.

STORED LUMINANCE: The luminance of stored information at a given operating voltage.

STORAGE MODE: The mode of operation that permits the storage target to retain written information.

STORAGE TARGET: A surface having the ability to store information when bombarded by an electron beam.

STORAGE TARGET BACKPLATE: A conductive surface electrically coupled to and usually physically supporting the storage target.

STORED RESOLUTION: A measure of the tubes capability to display discrete elements of stored information; usually defined by the number of line pairs resolvable per centimeter on the tube face.

STORED WRITING RATE: The reciprocal of stored writing speed (seconds per centimeter or other units).

STORED WRITING SPEED: The speed (centimeters per second or other units) at which the writing beam will register stored information when scanning the storage target, under stated conditions of operation.

UPPER WRITING LIMIT: The highest operating voltage at which a signal can be written and still maintain a given stored resolution under given conditions of operation.

WRITE: To bombard the phosphor screen with electrons and produce luminescence.

WRITTEN STATE: The stable mode of any area of a storage target after writing and before erasure.

WRITING GUN: A high-energy electron gun giving a narrow focused beam which can be deflected, and is used to write the information to be stored.

WRITING THRESHOLD: The lowest operating voltage at which a signal can be written and completely stored under given conditions of operation.

BASIC OPERATING PRINCIPLES OF THE STORAGE TUBE

The Tektronix T4501 CRT is a direct-view storage cathode ray tube. The storage target stores electrical charges on an insulated surface by using the secondary emission properties of the surface. The stored charge is then used to control the flow of electrons to a phosphor screen to give visual output that corresponds to the location of the stored charge.

The storage cathode ray tube contains special storage elements in addition to the conventional writing gun element. The operating mode of the tube depends primarily on the voltages applied to these storage electrodes. With one condition of applied potentials, the storage screen or target operates in the ready-to-write state; then, when it is bombarded with high energy writing beam current, it shifts to the stored mode to store a written display.

The storage screen contains a special coated surface which continues to emit light when bombarded by the flood gun electrons, provided the surface has been written by the writing gun beam and shifted to the stored state.

Fig. 3-1 illustrates the basic construction of the T4501 storage tube. The flood guns emit two cones of electrons which completely cover the storage target. The collimation electrodes shape the flood beam. The operating level of the tube is the potential difference between the target backplate and the flood gun cathodes.

In the erased, or ready-to-write mode the insulator surface of the target tends to charge down a potential lower than the backplate potential, and towards the potential of the flood gun cathode. This is due to the ratio of primary current (flood gun beam) to target secondary emission current. The potential to which the target charges is called the rest potential. This potential is such that the flood gun electron landing energy is not enough to illuminate the phosphor in the target. The target is now ready to write. See Fig. 3-2.

In the writing process, the target is scanned by the writing gun electrons. These high energy electrons increase the target secondary emission over the area they scan, so that the ratio of primary current to secondary current becomes greater than one. When this ratio exceeds one, that part of the bombardment surface shifts to a new stable state. Writing has been accomplished and this segment of the target is now stored.

In the written state, the potential difference between the flood gun cathode and target becomes greater and the flood gun electrons now have a landing energy that is sufficient to provide a visual display due to the cathode luminescence of the phosphor-impregnated target. This visual display will continue as long as the flood gun beam covers the target.

At high sweep rates, the writing beam current is not adequate to bring the portion of the target scanned above the crossover point; therefore, the flood gun electrons when landing on the bombarded area will remove the charge developed by the writing gun electrons, and the target will discharge to its initial ready-to-write state without being written. Thus, complete writing is a function of writing beam current density.

When the stored display is no longer desired, the information is erased by a waveform cycle as illustrated in Fig. 3-3. A positive going pulse is first applied to the flood gun target to increase the flood gun cathode-to-backplate difference of potential and write the entire target area with flood gun electrons. Next, as the flood guns are returned to their operating level, the backplate voltage is pulled well below the rest potential. Then as the backplate voltage is gradually

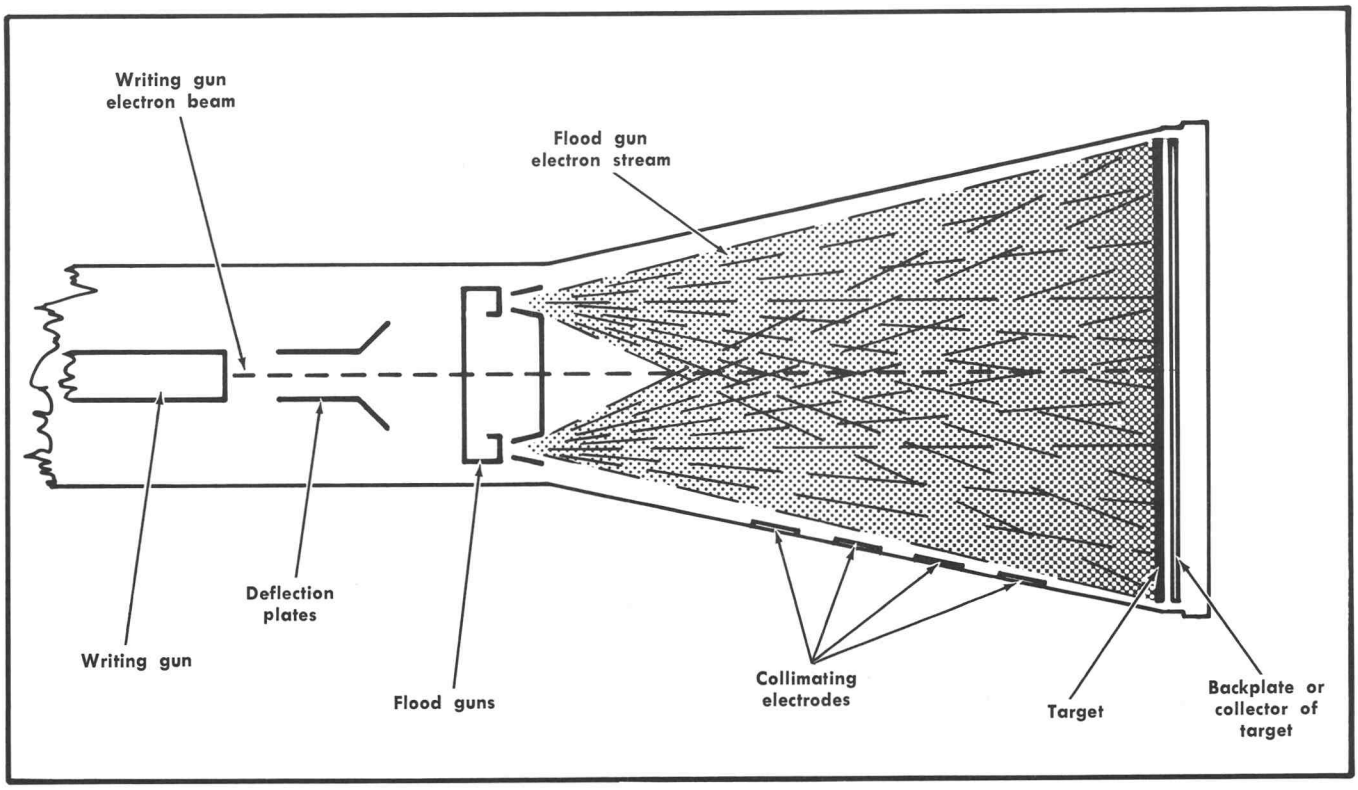


Fig. 3-1. Pictorial diagram of storage tube Type 4501.

returned, the target is charged to the rest potential and the target is now in the ready-to-write state.

If a more complete study of storage tube operating principles is desired, a Tektronix Circuit Concepts paperback book entitled "Storage Cathode-Ray Tubes and Circuits" is available through your local Tektronix, Inc., Field Office or representative. Tektronix Stock No. 062-0861-01.

BLOCK DIAGRAM DESCRIPTION

The Read Raster circuit contains an oscillator that runs at two times the television horizontal rate (either 525 line or 625 line). The output of the oscillator triggers binary counters composed of J-K flip flops and one-shot multivibrators that are made up of integrated circuits. The outputs of the binary counters and the one-shot multis are coupled into NOR gates where they are combined to form the composite sync and composite blanking signals. The outputs of the counters and the multis also develop the vertical and horizontal ramps which scan the storage CRT at the television rate, the vertical and horizontal drive signals used to program remote equipment, the Read Amplifier clamp and blanking gate, the switching signals used in the X, Y and Z Axis amplifiers to time-share, and the blanking ears (see Fig. 3-10) that inhibit the output of the Z Axis amplifier during switching. External composite sync and composite blanking signals can be coupled into the Type 4501 if desired. When external signals are used, both composite sync and composite blanking must be coupled into the Read Raster circuit at the same time so the circuit will function properly. When external signals are used, the internally generated signals are inhibited.

The storage CRT beam current for both the write and read functions is controlled by the Z Axis Amplifier circuit. During read time, the Z axis output level is determined by the Read Intensity control, an internal adjustment. During write time, the Z axis output level is determined by the front panel INTENSITY control in conjunction with the external signal connected to the Z axis input connectors. The input to the Z Axis Amplifier is a differential input; therefore, common-mode signals will be rejected. The + input is non-inverting and a + signal on it will increase CRT beam current. The − input inverts the input signal and a positive signal on it will decrease the CRT beam current.

External signals are coupled to the horizontal and vertical deflection plates of the storage CRT through the X (horizontal) and Y (vertical) input amplifiers. Both amplifiers have a differential input, which provides good common-mode rejection. Also coupled into the X-Y Amplifiers are the horizontal and vertical ramps, which are occurring at the television rate and are used to scan the written area of the storage CRT so it can be displayed on television

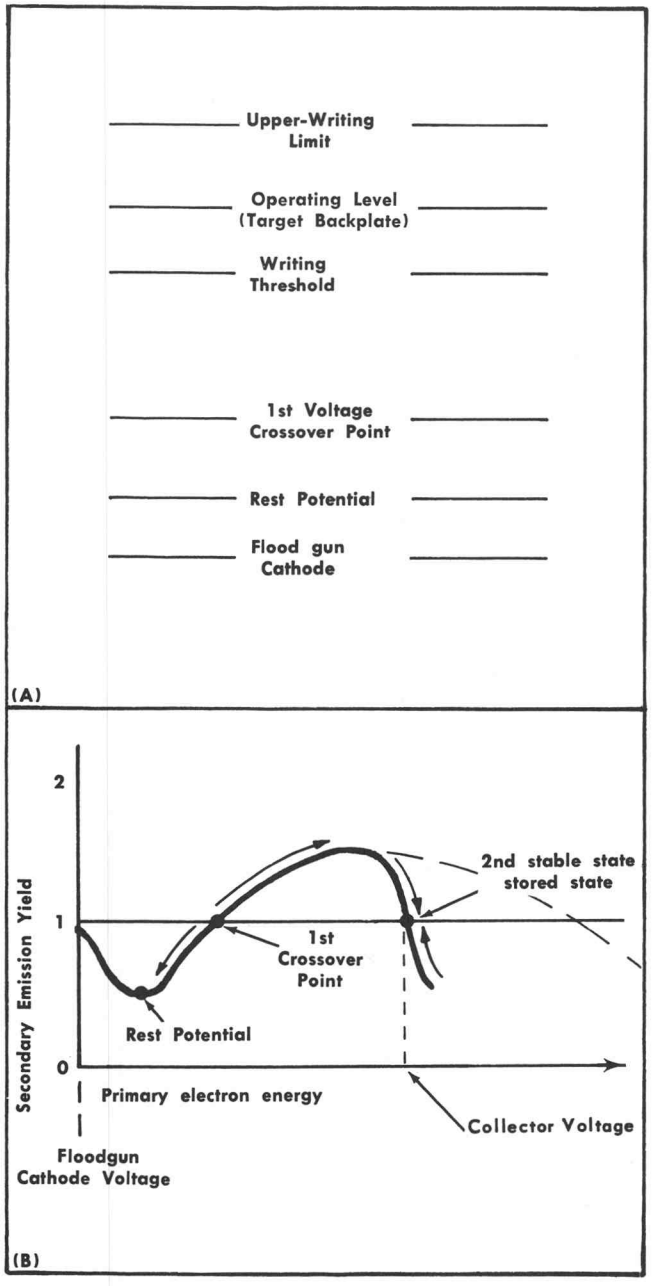


Fig. 3-2. (A) Relative scale of characteristic storage-tube operating potentials; (B) secondary emission curve for insulator showing charging.

monitors. The input signal or writing signal and the ramps are time-shared and controlled by a switching signal developed in the Read Raster circuit. The POSITION controls control the position of the writing signal, but do not affect the positioning of the scanning ramps.

The storage circuit provides the voltage levels necessary to operate the flood guns and the collimation electrodes of the storage CRT. The storage circuit generates an erase pulse, which is manually controlled, to erase the written information. During the erase cycle, a negative-going pulse of the same time duration as the complete erase cycle is produced by the erase interval circuit. This pulse is coupled to the Read Raster circuit where it develops the Read Amplifier blanking pulse that gates the Read Amplifier off during the erase cycle. The pulse from the storage circuit can also be used to notify associated equipment that the Type 4501 is being erased.

The stored display is scanned at the television rate and coupled from the CRT target to the Read Amplifier circuit. The composite sync signal developed in the Read Raster circuit is also coupled into the Read Amplifier, and the two signals are mixed to produce a composite video signal. The composite video signal is available at the output connector on the rear of the instrument. The composite signal is also coupled into a modulator, where it modulates an RF carrier. The carrier frequency is tunable from 54 MHz through 72 MHz, which corresponds to U.S. television channels 2, 3 and 4. The modulated carrier is also available at an output connector on the rear of the instrument. The polarity of the output signal from the Read Amplifier is selectable as either a positive- or negative-going video signal. This permits the signal to be viewed on the monitors as either a dark signal on a light background or a light signal on a dark background.

The CRT circuit provides the voltage levels required to operate the CRT. An oscillator and transformer produce

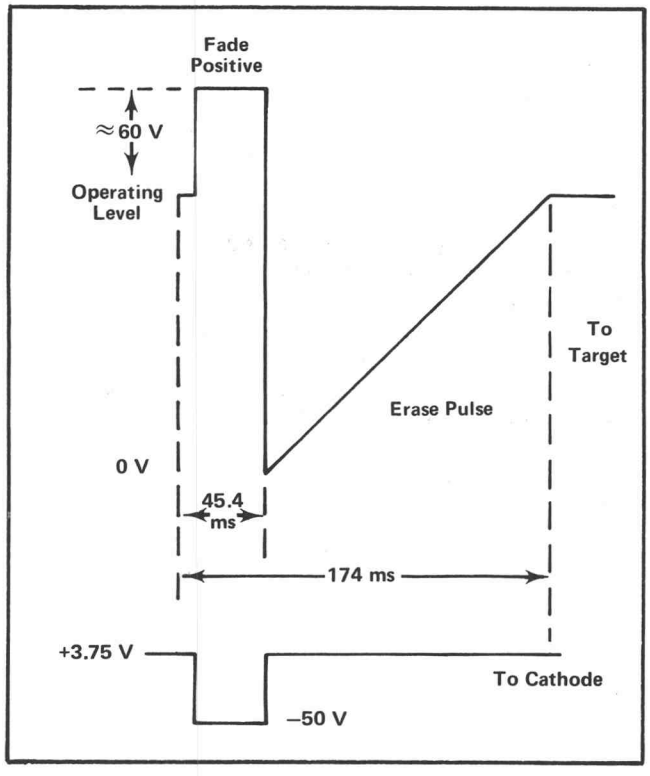
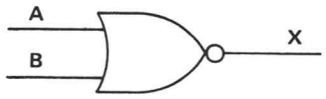


Fig. 3-3. Typical erase cycle waveform.

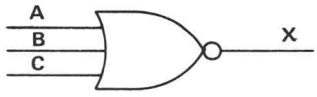
TABLE 3-1

Truth table for NOR gates used in Read Raster circuit, positive logic.

1 = > +0.9 V		
A	B	X
0	0	1
0	1	0
1	0	0
1	1	0



0 = < 0.5 V			
A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0



the high-voltage, which is rectified and applied to the CRT cathode and grid. A regulator circuit maintains the high voltage at a constant level. The CRT is biased on by unblanking signals from the Z Axis Amplifier circuit. Controls are provided to adjust the CRT for optimum display.

DETAILED CIRCUIT DESCRIPTION

READ RASTER

General

The purpose of the Read Raster circuit is to develop the switching signals, gating signals, clamps, television signals such as composite blanking and composite sync, and the vertical/horizontal ramps used to scan the storage CRT at the television rate. The circuit contains a clock (oscillator) which runs at two times the television horizontal rate. The clock is used to trigger one-shot multivibrators and a binary counter that counts down to produce the television vertical rate. The pulses formed by the counters and the multivibrators are coupled into NOR gates, and combine to form the vertical interval, composite sync, and composite blanking. External composite sync and composite blanking can also be coupled into the Read Raster circuit. When external composite sync and composite blanking signals are coupled into the Type 4501, the internally generated signals are inhibited from the output connector and are used for triggering within the Type 4501.

The gates used in the Read Raster circuit are NOR gates. A truth table for them is given in Table 3-1. Positive logic is used throughout the Read Raster circuit description. The logic levels are: 1 = > +0.9 V. 0 = < +0.5 V. When all the inputs to a gate are in the 0 condition, the output of the gate will be 1. If a 1 exists on any of the inputs, the output of the gate will be in 0 regardless of the condition of the other inputs.

The counters used in the Read Raster circuit are J-K flip flops. Two J-K flip flops are contained in each integrated circuit; therefore, there are two sets of pin numbers for the J-K flip flops used in the Read Raster circuit. For the following discussion of J-K flip flops, only one set of pin numbers will be used and the corresponding pin numbers for the other flip flop will have the same function as those described. Pin 12 is the preset pin and when it is in the 1 state, pin 13 will be in the 0 state. Pins 13 and 14 are the output pins. When the preset pin goes to the 0 state, the multi is released to change stages but will not do so until the arrival of the next negative-going clock pulse. Pin 2 receives the clock pulse, and a negative-going pulse is required to flip the multi. Pin 3 is the SET and pin 1 is the CLEAR. When a 1 is applied to the set pin, pin 13 will go to the 1 state on the next clock pulse and remain in this condition until the 1 is removed from the set pin. If a 1 is applied to the clear pin, pin 14 will go to the 1 state on the next clock pulse and remain in this condition until the 1 is removed from the clear pin.

Oscillator

The oscillator circuit, which is used as the clock for the Read Raster circuit, is basically a crystal-controlled multivibrator. The circuit contains two crystals that are selectable. When the instrument is used in 525 line operation, Y17 (whose frequency is 31.5 kHz) is selected. In 625 line operation, Y13 (with a crystal frequency of 31.25 kHz) is selected. When the 525/625 switch is in the 525 position, a ground is connected to the cathode of CR14, which forward biases the diode and disables the 31.25 kHz crystal. If 625 line operation is selected, the ground is removed from CR14 and a logical 1 is connected to its cathode, reverse biasing CR14. The logical 1 is coupled through U48F, an inverter. A logical 0 appears at the output, pin 7, of U48F which forward biases CR18 and disables the 31.5 kHz crystal, allowing the 31.25 kHz crystal to operate.

The output of the 31.5 kHz crystal is coupled through R17/C17 to the base of U3A. C12, which is across the base-emitter junction of U3A, is also effectively across the parallel capacitance of the crystal. This increases the parallel capacitance of the crystal and insures that it operates as a series resonant circuit. The signal is coupled through U3A to the base of U3B. The signal on the collector of U3B is of the same polarity as the signal on the base of U3A. This signal is divided down through R24, R18 and fed back to drive the crystal. The signal on the collector of U3B is coupled through C90 and triggers the vertical offset multi on the positive-going portion of the waveform. The signal on the collector of U3B is also coupled to the base of U3E, which inverts the signal and couples it to the number 1 binary counter and the ÷2 counter. The counters are J-K flip flops; therefore, they will be triggered on the negative-going portion of the waveform. The counters and the vertical offset multi are triggered in coincidence since the pulse to the counters has been inverted by U3E. Diode CR15, connected from the junction of R14, R15, and R18 to ground, insures that the anodes of CR14 and CR18 will be slightly positive, causing the diodes to turn on hard when a ground is applied to either of their cathodes.

One-Shot Multivibrators

The clock pulse, which is occurring at a 31.5 kHz rate, is applied to pin 2 of U92A. U92A and U9E form the vertical offset multi. The timing capacitor and resistor for the multi are C92 and R92. Fig. 3-4 illustrates the time relationship of the multivibrators, the clock, and the ÷2 counter. Fig. 3-5 illustrates the time duration of the multivibrators, the blanking ears (which are derived from the horizontal blanking and switching gate), and the horizontal drive pulse (which is derived from the horizontal sync and the front porch). The primary purpose of the vertical offset pulse is to develop the serrations in the vertical sync pulse. The vertical offset pulse is coupled from pin 6 of U9E to pin 1 of U46A and to pin 6 of U43B. Pin 7 of U43B is connected to pin 3 of U5C, which remains in the 0 state when there are no external sync and blanking inputs. Therefore, the vertical offset pulse is coupled through and inverted by U43B and applied to pin 7 of U92B. Pin 6 of U92B is connected to ground through R135 and, since no external sync and blanking inputs are being coupled into the circuit, pin 6 is at ground potential or in the 0 state. Therefore, the vertical offset pulse is inverted by U92B and appears as a positive-going pulse on pin 5 of U92B. The pulse is differentiated by C94 and R94, then coupled through inverter U5F to the inputs of the front porch, switch delay, and horizontal blanking multivibrators. The one-shot multis in the Read Raster circuit require a positive-going trigger; therefore, the multis (front porch, switch delay, and horizontal blanking) trigger on the trailing edge of the vertical offset pulse. See Fig. 3-5.

The front porch multi consists of U94B and U9D with C95 and R95 the timing capacitor and resistor. Appearing on the output, pin 5 of U9D, is a positive-going pulse. The pulse is differentiated by C96 and R96 and inverted by U41C. The positive-going differentiated pulse is then used to trigger the equalizing pulse multi and the horizontal sync multi. The timing capacitor and resistor for the equalizing pulse multi are C98 and R98, and the timing capacitor and resistor for the horizontal sync multi are C97 and R97. The pulse out of each of the multis is a positive-going pulse.

The horizontal sync multi is being triggered at two times the television horizontal frequency; therefore, the output of the multi must be divided by 2. This is accomplished by applying the clock pulse from the oscillator (pin 14 of U3E) to pin 2 of U39A, a ÷2 counter. The output from pin 14 of U39A (B of Fig. 3-4) then is coupled through inverter U48C, and is applied as an inhibit signal to pin 9 of U94C. When pin 9 of U94C is in the 1 state, the output of the multi will be in the 0 state regardless of the trigger being applied to pin 12 of U94D. By referring to Fig. 3-4 B, D, and G, it can be determined that the output of the horizontal sync multi is inhibited on every other trigger input (front porch) and the output is at the television horizontal rate.

The output of the horizontal sync multi is coupled to pin 13 of U8D. U8D and U8C form the one-shot to develop the switch gate (j of Fig. 3-4). The timing capacitor and resistor for the multi are C99 and R99.

The positive-going pulse that triggers the front porch multi also triggers the switch delay multi and the horizontal blanking multi (Fig. 3-5 C and E). The timing capacitor and resistor for the switch delay multi are C110 and R110. The timing capacitor and resistor for the horizontal blanking multi are C145 and R145. Both multis are inhibited on every other trigger pulse (Fig. 3-4 C, E, and F) in the same manner as previously described for the horizontal sync multi. The output of the switch delay multi is coupled through a differentiator, C112 and R112 and through inverter U5D. It then triggers the switch drive multi (Fig. 3-5 E and F). The timing capacitor and resistor for the multi are C114 and R114.

The output of the switch drive multi is inhibited during the time the WRITE ONLY, WRITE AND READ, READ ONLY switch is in the READ ONLY position, or Raster write is programmed. When the switch is placed in the READ ONLY position, a ground is connected to the cathode of CR116 or CR117. This causes current to flow through the diode, which in turn causes the voltage on the anode of the diode to become less positive. This change is coupled through CR118 and CR119, causing pin 14 of U76A to go to the 0 state. U76A is an inverter; therefore, pin 1 of U76A goes to the 1 state, putting a 1 on pin 7 of U110B. The output of the switch drive multi will now remain in the 0 state until the ground is removed from the cathode of CR116 or CR117.

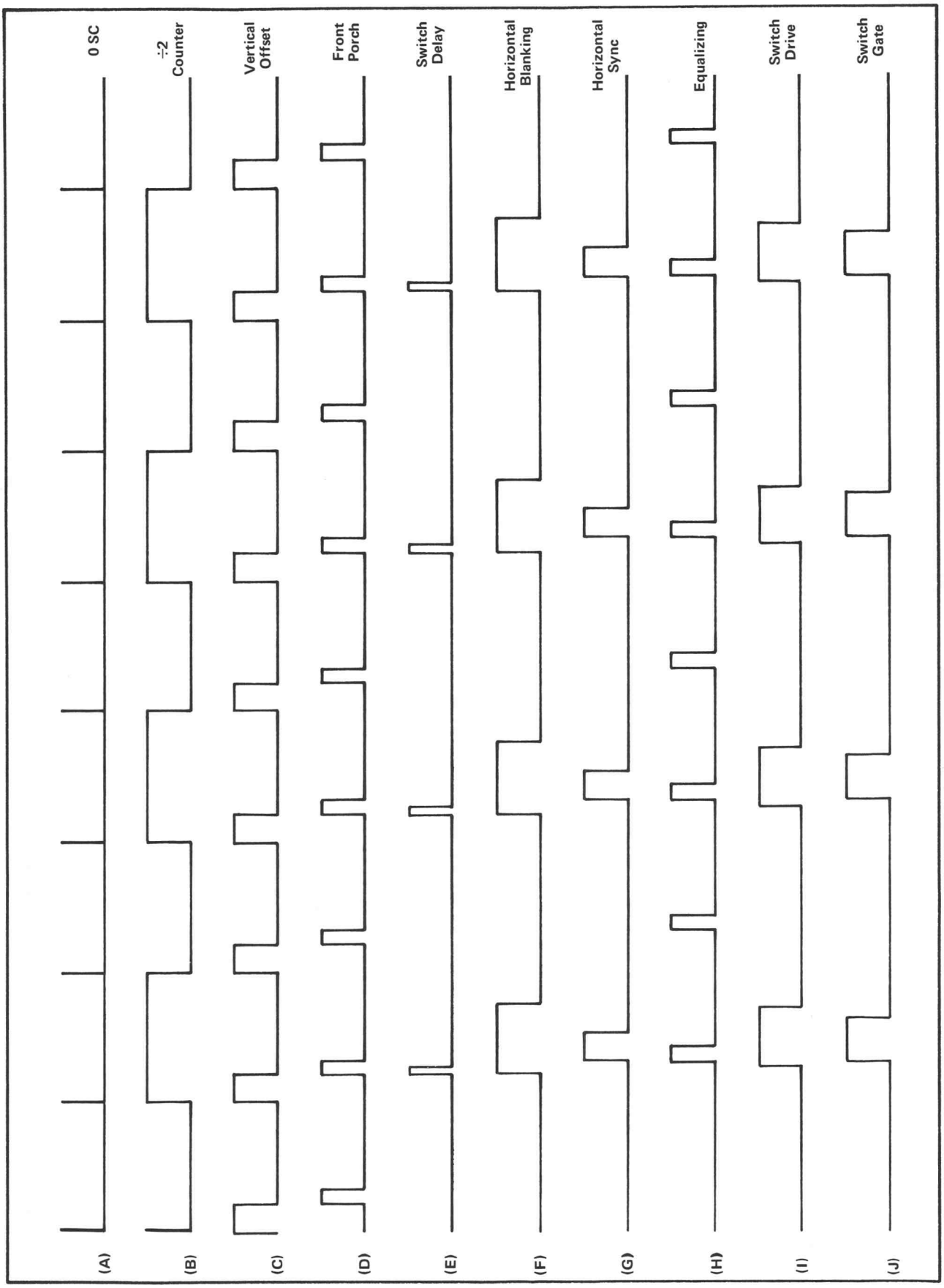


Fig. 3-4. Waveforms illustrating the time relationship of the multivibrators, oscillator, and ÷2 counter outputs.

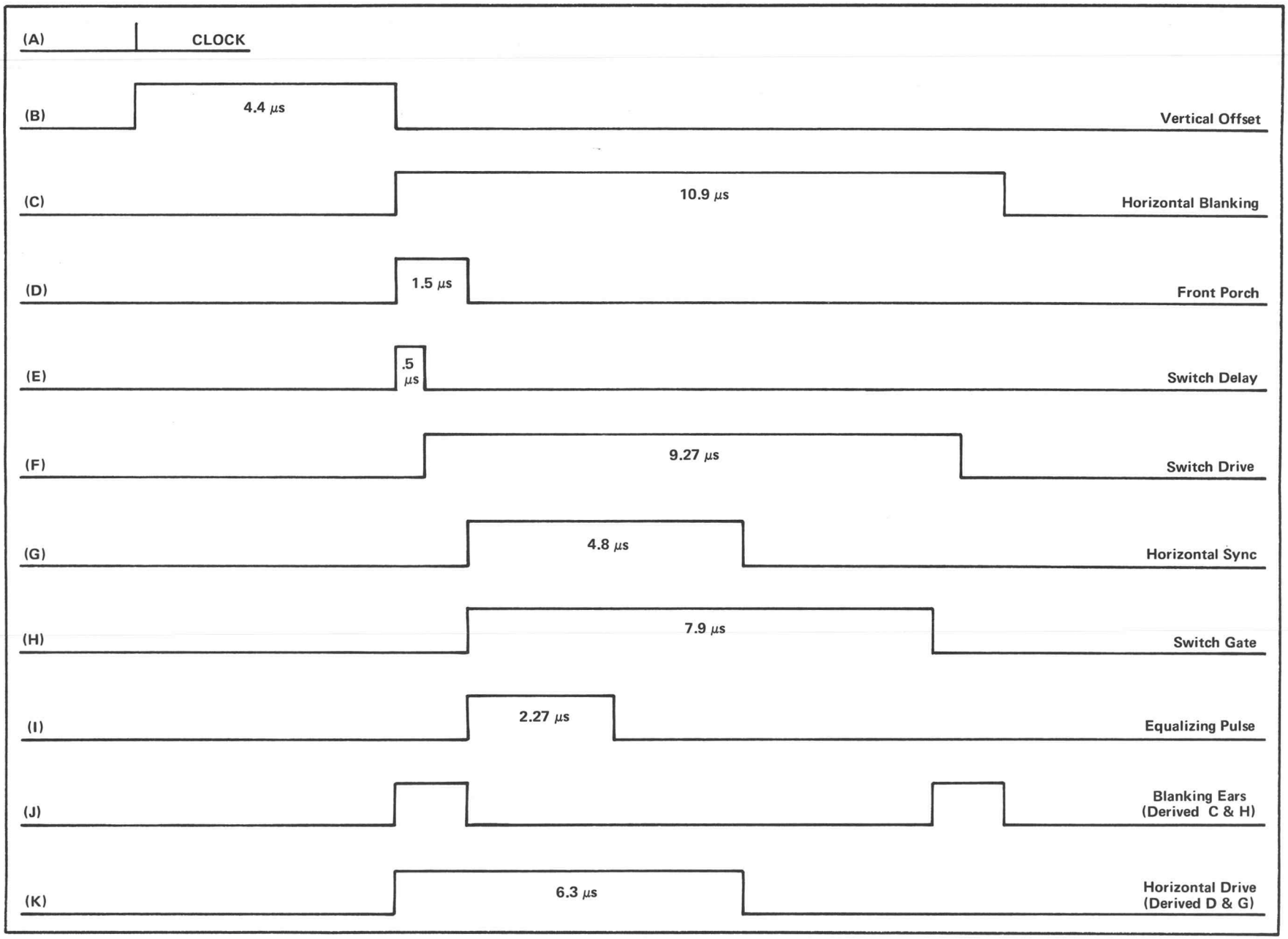


Fig. 3-5. Waveforms illustrating the time duration of the multivibrator outputs in the Read Raster circuit.

512 Binary Counters

The binary counters used in the Read Raster circuit are J-K flip flops and the function of the pins have been previously explained under the sub-title of General in this circuit description. The clock pulse that triggers the one-shot multivibrators is inverted by U3E, and it triggers the counters. The pulse is applied to pin 2 of U30A, the first flip flop in the binary sequence. Table 3-2 is a truth table for the counters and Fig. 3-6 illustrates the time relationship of the output waveforms of the counters, which are used to develop other waveforms in in the Read Raster circuit. Also illustrated in Fig. 3-6 are four of the waveforms that are developed from the counter output.

When the equipment is initially turned on, the first flip flop in the binary sequence will be triggered by the first clock pulse and the counter will start counting. When the count reachs binary number 512, all the counters except 512 will be in the 0 state (see Table 3-2). At this time pin 13 of U38A will go to the 0 state. The signal on pin 13 is differentiated by C41/R41 and coupled through two inverters in parallel, U41E and U41F. A positive-going spike appears at the output of each inverter. The output from pin 7 of U41F is coupled to binary counters 1, 2, 128, and 256 as a preset pulse. The output from pin 6 of U41E is coupled to counters 16, 32, and 64 (525/625 switch in 525 position) as a preset pulse. The preset pulse causes pins 8 and 14 to go to the 1 state producing count 1011; see Table 3-2. The counters continue counting through 1023, at which time the count starts over with binary count 0. At binary count 0, the output pins 8 and 14 of the counters are in the 0 state. Television vertical blanking occurs at this time and the vertical group is developed during the next forty counts.

Vertical Group

When the binary count becomes 0, the output of the 512 counter goes to the 0 state and triggers J-K flip flop U39B. Prior to the occurrence of the 0 count, U39B has been preset by the output of U43A. Because of the slight delay in the counter, it is released prior to the trigger from the 512 counter. Therefore at the 0 count, when U39B is triggered, pin 9 goes to the 1 state (see Fig. 3-6 L) and remains there until U39B receives another preset pulse from U43A. The two inputs to U43A are from pin 9 of counters 8 and 32. Therefore when pin 8 of counter 8 and 32 are in the 1 state, both inputs to U43A will be in the 0 state and the output of the gate will go the 1 state. Pin 10 of U39B will then receive a preset pulse and pin 9 of U39B will go to the 0 state ending the vertical blanking pulse. The vertical blanking pulse is terminated at count 40 (see Fig. 3-6 E, G, and L and Table 3-2). Pin 7 of U39B is the clear pin and is connected to the External Composite Blanking In circuit. Since no external signals are being coupled into the Read Raster circuit, the output of U76F remains in the 0 state.

At the beginning of the vertical blanking pulse, pin 9 of U39B goes to the 1 state. This positive-going pulse is coupled through a differentiator, C43/R43, and appears as a positive-going spike on pin 1 of U45A. U45A and U44C are connected in a flip flop configuration. A 1 on the input of U45A causes the output, pin 3, to go to the 0 state (see Fig. 3-6J). The output of U45A is coupled to pin 6 of U44C, a three input gate. To determine the condition of output pin 5 of U44C, it is necessary to first determine the condition of the other two inputs. Pin 7 of U44C is connected to the output of U44A, pin 3. One of the inputs to U44A is from inverter U48F, which is connected to the 525/625 switch. Since the switch is in the 525 position, a ground is connected to the input of the inverter and the output of the inverter is in the 1 state. Therefore, pin 2 of U44A is in the 1 state and the output of the gate will be in the 0 state regardless of the condition of the other two inputs. Pin 7 of U44C is therefore in the 0 state. Pin 8 of U44C receives its signal from pin 5 of U45B, another gate. The inputs of U45B are from pin 13 of binary counter 16 to pin 6 of U45B and from pin 8 of binary counter 2, through inverter U9F to pin 7 of U45B. Pin 13 of counter 16 is in the 1 state at this time (see Fig. 3-6 F), therefore the output of U45B will be in the 0 state. This establishes a 0 state at all three inputs of U44C and causes output pin 5 to assume the 1 state. A 1 on pin 2 of U45A keeps output pin 3 in the 0 state. Since pin 1 of U45A is capacitively coupled to pin 9 of U39B, it returned to the 0 state at the completion of the positive spike which occurred at the beginning of vertical blanking.

To cause the multi to flip to the other state, it must receive a 1 on pin 8 of U44C. This means the two inputs to U45B must be in the 0 state, which will occur when pin 8 of binary counter 2 and pin 14 of binary counter 16 are in the 1 state at the same time. This condition exists at count 18 (see Fig. 3-6 C and F). At this time pin 5 of U45B goes to the 1 state, causing the output of U44C to go to 0 state. Both inputs of U35A now have zero applied; therefore, the output of U45A will go to the 1 state (see Fig. 3-6 J).

One of the outputs of U45A (pin 3) is coupled to U44B (pin 13), and the output of U44B is coupled to a flip flop consisting of U90C/U43D. One way of determining the state of the multi at this time is by looking at the input to U90C (pin 7). The signal to U90C (pin 7) is received from U70C (pin 8). The two inputs to U70C are from pin 13 of counter 4 and pin 9 of counter 8. By referring to Table 3-2 or Fig. 3-6 D and E, it can be determined that the inputs of U70C are both in the 0 state. Therefore, the output of U70C is in the 1 state, which applied a 1 to the input of U90C causing U90C (pin 5) to assume the 0 state. U43D (pin 14) must therefore be in the 1 state; see Fig. 3-6 I. To cause the multi to change states, U43D (pin 12) must receive a 1 from U44B (pin 9). The inputs for U44B are received from pin 8 of binary counter 8, from U45A (pin 3), and from U43C (pin 8). By referring to Fig. 3-6 E and J, it can be determined that U44B pins (10) and (13) both are

TABLE 3-2

Truth table for 525 counter, pins 8 and 14, positive logic.

Clock Pulse	Counter Condition										
	512	256	128	64	32	16	8	4	2	1	
0	0	0	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	0	1	
2	0	0	0	0	0	0	0	0	1	0	
	count continues										
510	0	1	1	1	1	1	1	1	1	0	
511	0	1	1	1	1	1	1	1	1	1	
512	1	0	0	0	0	0	0	0	0	0	Preset occurs during this time period, producing count 1011.
1011	1	1	1	1	1	1	0	0	1	1	
1012	1	1	1	1	1	1	0	1	0	0	
1013	1	1	1	1	1	1	0	1	0	1	
	count continues										
1021	1	1	1	1	1	1	1	1	0	1	
1022	1	1	1	1	1	1	1	1	1	0	
1023	1	1	1	1	1	1	1	1	1	1	
0	0	0	0	0	0	0	0	0	0	0	— Vertical blanking sets
1	0	0	0	0	0	0	0	0	0	1	
2	0	0	0	0	0	0	0	0	1	0	
3	0	0	0	0	0	0	0	0	1	1	
4	0	0	0	0	0	0	0	1	0	0	
5	0	0	0	0	0	0	0	1	0	1	
6	0	0	0	0	0	0	0	1	1	0	
7	0	0	0	0	0	0	0	1	1	1	
8	0	0	0	0	0	0	1	0	0	0	
9	0	0	0	0	0	0	1	0	0	1	
10	0	0	0	0	0	0	1	0	1	0	
11	0	0	0	0	0	0	1	0	1	1	
12	0	0	0	0	0	0	1	1	0	0	
13	0	0	0	0	0	0	1	1	0	1	
14	0	0	0	0	0	0	1	1	1	0	
15	0	0	0	0	0	0	1	1	1	1	
16	0	0	0	0	0	1	0	0	0	0	
17	0	0	0	0	0	1	0	0	0	1	
18	0	0	0	0	0	1	0	0	1	0	
19	0	0	0	0	0	1	0	0	1	1	
20	0	0	0	0	0	1	0	1	0	0	
21	0	0	0	0	0	1	0	1	0	1	
22	0	0	0	0	0	1	0	1	1	0	
23	0	0	0	0	0	1	0	1	1	1	
24	0	0	0	0	0	1	1	0	0	0	
25	0	0	0	0	0	1	1	0	0	1	
26	0	0	0	0	0	1	1	0	1	0	
27	0	0	0	0	0	1	1	0	1	1	
28	0	0	0	0	0	1	1	1	0	0	
29	0	0	0	0	0	1	1	1	0	1	
30	0	0	0	0	0	1	1	1	1	0	
31	0	0	0	0	0	1	1	1	1	1	
32	0	0	0	0	1	0	0	0	0	0	
33	0	0	0	0	1	0	0	0	0	1	
34	0	0	0	0	1	0	0	0	1	0	
35	0	0	0	0	1	0	0	0	1	1	
36	0	0	0	0	1	0	0	1	0	0	
37	0	0	0	0	1	0	0	1	0	1	
38	0	0	0	0	1	0	0	1	1	0	
39	0	0	0	0	1	0	0	1	1	1	
40	0	0	0	0	1	0	1	0	0	0	— Vertical blanking resets.
41	0	0	0	0	1	0	1	0	0	1	
42	0	0	0	0	1	0	1	0	1	0	
43	0	0	0	0	1	0	1	0	1	1	

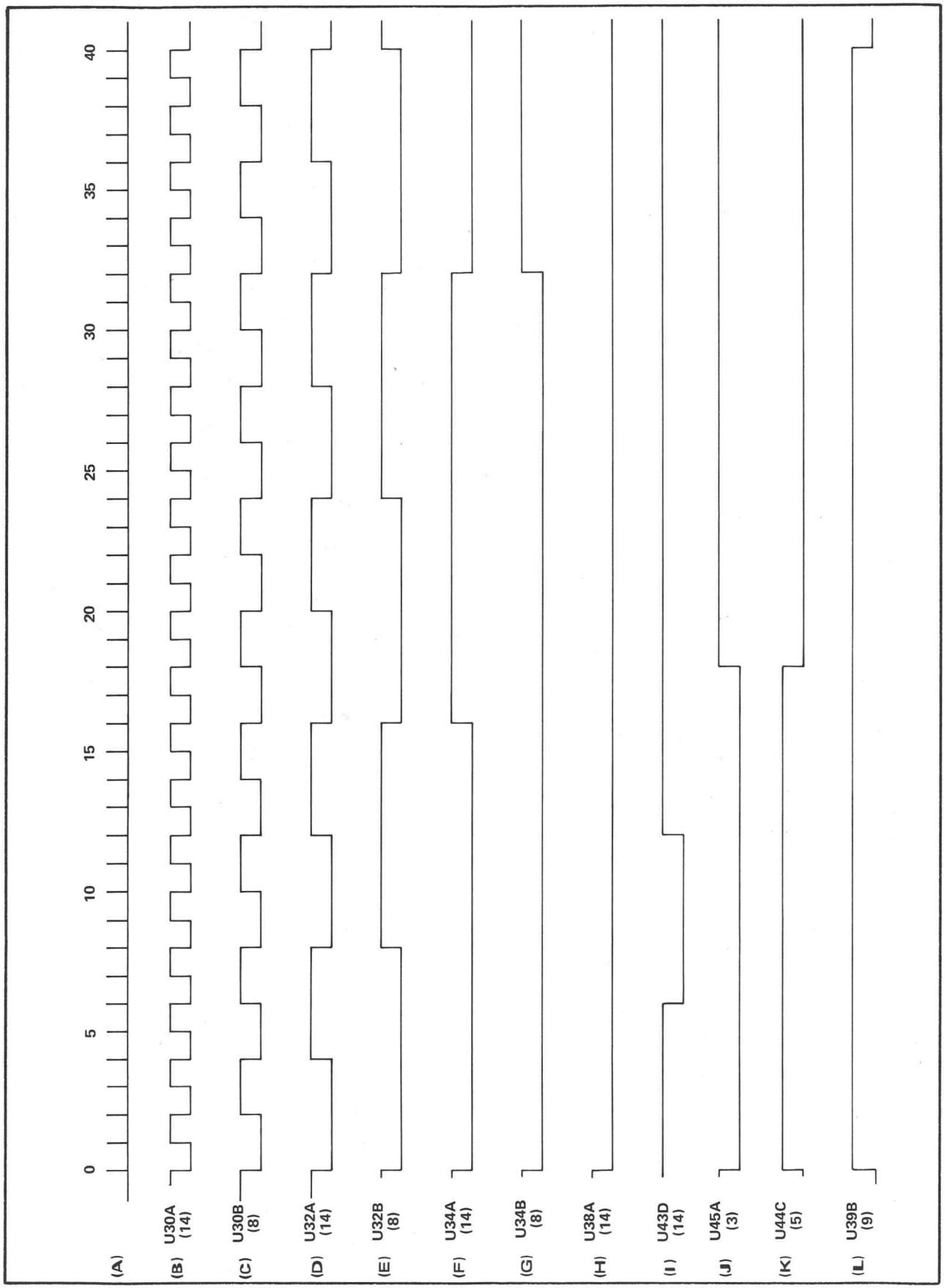


Fig. 3-6. Waveforms illustrating the outputs of the binary counters (pins 8 and 14) and four waveforms that are developed from them.

in the 0 state at this time. Therefore, if U44B (pin 12) receives a 0 U44B (pin 9) will go to the 1 state. U44B (pin 12) receives its signal from U43C (pin 8), and the two inputs to U43C are from U90B and U45C. To produce a 0 at U43C (pin 8), one of its inputs must be in the 1 state. U43C (10) receives its signal from U90B (9), and one of the inputs to U90B is from the 525/625 switch through inverter U48F. Therefore, as previously explained for U44A (3), the output of U90B will remain in the 0 state. The other input to U43C is from U45C (8). The inputs to U45C are from pin 8 of binary counter 2 through inverter U9F to U45C (10) and from pin 13 of binary counter 4 to U45C (9). It can be determined, by referring to Fig. 3-6 C and D, that both inputs to U45C will be in the 0 state at count 6. This causes U45C (8) to go to the 1 state, producing a 0 at U43C (8). Now all the inputs to U44B are in the 0 state; therefore, U44B (9) will assume the 1 state causing the multi to flip (see Fig. 3-6 I). U43D (14) will remain in the 0 state until one of the inputs to U90C assumes the 1 state, at which time the multi will again change states.

One of the inputs to U90C is from U90A (3), which receives one of its inputs from the 525/625 switch producing a 0 at U90A (3). The other input to U90C is from U70C (8) and as previously explained, U70C receives its inputs from binary counters 4 and 8. When both inputs to U70C are in the 0 state, U70C (8) will assume the 1 state and flip the multi. By referring to Fig. 3-6 D, E, and I, it can be determined that the multi changes states at count 12.

The output from U43D (14) is coupled to U46A (14). L46 and R46 are a pulse stretching network which delays the fall of the pulse. The other two inputs to U46A are from the vertical offset multi and the front porch multi. L93 and R93 delay the fall of the pulse from the vertical offset multi. Fig. 3-7 A, B, and C illustrates the three inputs to U46A and Fig. 3-7 D illustrates the output. The output, which is the serrated vertical pulse, is coupled to U46B (10). The signal at U45A (3) and the equalizing pulses from the equalizing-pulse multi are also coupled into U46B. The three inputs and the output of U46B are illustrated in Fig. 3-8 A, B, C, and D. The signal at U46B (9) is the portion of the vertical blanking containing the equalizing pulses and the serrated vertical sync pulse.

The signal on U46B (9) is coupled U46C (8), a three input gate. Also coupled into U46C is the signal from the Composite Blanking In circuit consisting of U3D/Q140, through an inverter (U76F) to U46C (6). Since no external signals are being coupled into the Read Raster circuit, the output of U76F will be in the 0 state. The other input to U46C is from U70D (14) to U46C (7). U70D is a two input gate whose inputs are from U44C (5) (see Fig. 3-6 K) and the horizontal sync pulses from the horizontal sync multi. The input and output waveforms of U46C are illustrated in Fig. 3-9 A, B. and C. U46C (5) is connected to U6C (10). The other input to U6C is from the External Composite Sync In circuit and, with no external signals coupled in, U6C (9) is in the 0 state. Therefore the signal from U46C (5) is inverted through U6C and appears as composite sync on U6C (8).

Output Signals

One output from U6C (8) is coupled to the base of Q62A. The signal is coupled through two amplifier stages and is available at the Composite Sync Output connector on the rear panel of the instrument. This signal meets EIA standards. VR65/CR64 sets the base voltage of Q66 at approximately −14 V with the transistor turned on, providing constant current through Q66. The other output from U6C (8) is coupled through inverter U48B, to the base of Q50. Q50 is the discharge transistor, or clamp, for the miller integrator circuit consisting of U55. The timing capacitor and resistor for the miller circuit are C50 and R51. Q50 is normally off, and C50 charges through R51. The

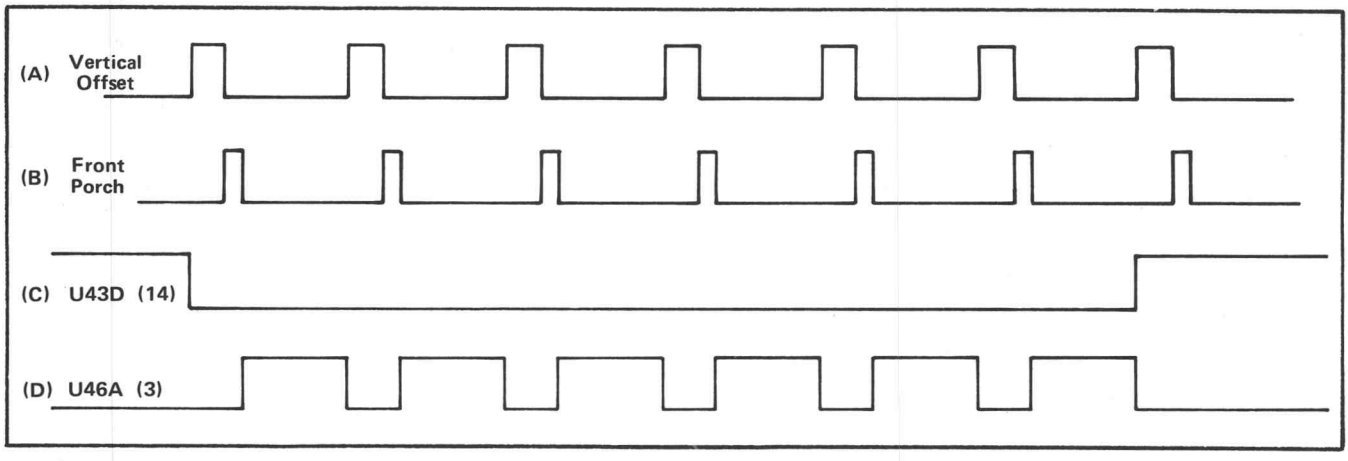


Fig. 3-7. Waveforms illustrating the inputs and output of U46A.

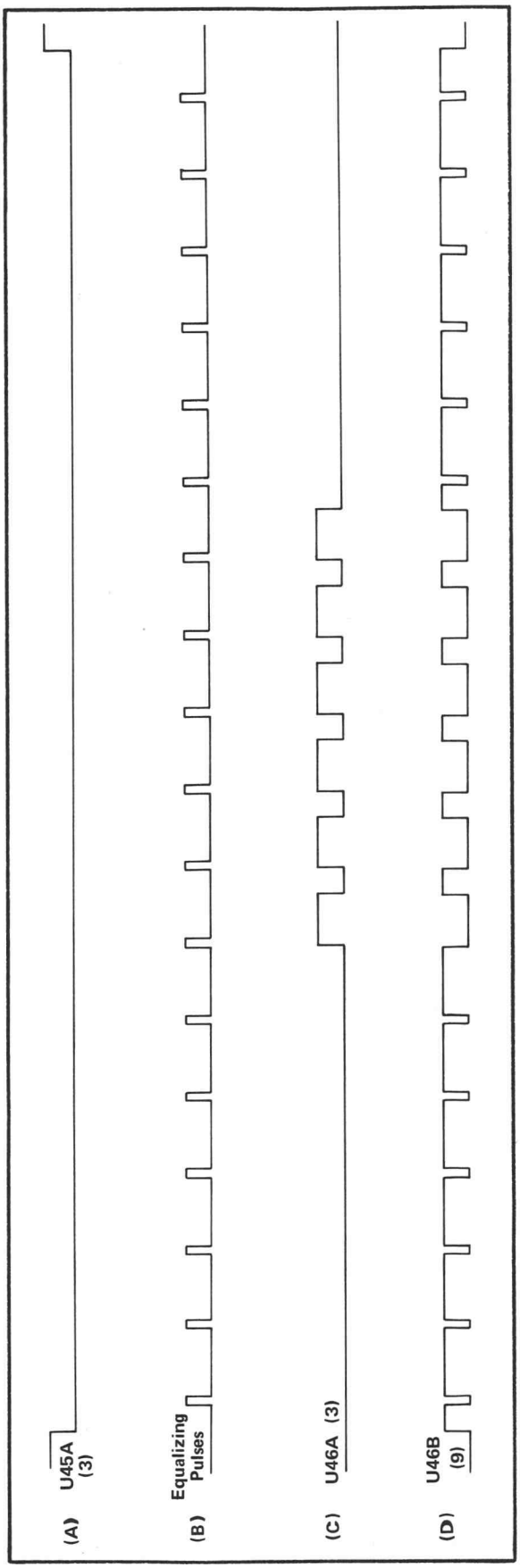


Fig. 3-8. Waveforms illustrating the inputs and output of U46B.

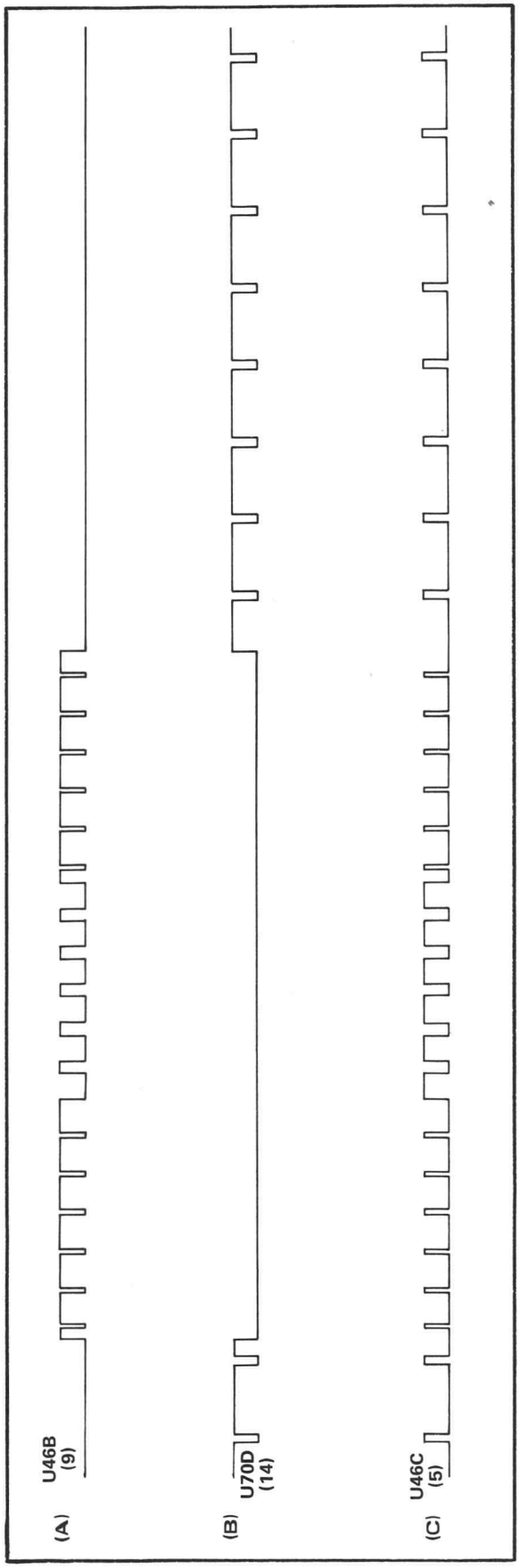


Fig. 3-9. Waveforms illustrating the inputs and output of U46C.

positive-going horizontal sync pulses turn on Q50 and discharge the capacitor. The ramp, which is of the same time duration as one horizontal television line, is coupled through linear amplifier U55 to the X-Y circuit where it is used to scan the CRT. R55 (H Ramp Position) sets the DC level of the ramp. Also, the signal at U48B is coupled through and amplifier, Q45, to the Read Amplifier circuit.

The pulse developed at U44C (5) (see Fig. 3-6 K), which is equivalent in time to the time duration of the vertical sync pulse and the equalizing pulses, is coupled through amplifier Q70A, and is available at the output connector on the rear panel as a vertical drive signal. The amplitude of the vertical drive signal out is from approximately +0.6 V to −5 V. The output of U44C (5) is also coupled to U70A (1), a two input gate. The other input of U70A is from U6A (3) in the external Composite Sync In circuit. With no external signals in, the output of U6A (3) remains in the 0 state; therefore, U70A acts only as an inverter to the signal from U44C (5). The output at U70A (3) is coupled through another inverter, U76B to the base of Q80 in the vertical ramp circuit. The vertical ramp circuit is identical in operation to the horizontal ramp circuit. The circuit is a miller integrator consisting of Q80 and U85. The timing capacitor and resistors are C80, R78, R79 and R81. Q80 is normally off and is turned on by the leading edge of the pulse from U44C (5). The transistor remains on for the duration of the pulse and then turns off. The timing capacitor is discharged during the on time of the transistor and charges during the off time. In 525 line operation, R78 is connected to ground through the 525/625 switch. When the Type 4501 is switched to 625 line operation, +3.75 volts is connected to R78 through the switch. This reduces the charging current to C80, thereby increasing the time duration of the vertical ramp. The vertical ramp position control is R85. The vertical ramp is coupled to the X-Y circuit and is used to scan the storage CRT.

The output of the switch drive multi is coupled to U70B (6), a two-input gate. The other input to the gate is from the WRITE ONLY switch, through an inverter (U76C) to U70B (7). When the switch is not in the WRITE ONLY position, U76C (12) is in the 1 state, causing U70B (7) to be in 0 state. This allows the output of the switch drive multi to be coupled through U70B to the base of Q122. The signal on the collector of Q122 is coupled to the base of Q124. The signal on the collector of Q124 is then a negative going switching pulse. A positive-going switching pulse is also available on the collector of Q128, which inverts the collector signal of Q124. These two switching signals are used in the X, Y, and Z circuits.

The output of the horizontal sync multi is coupled to U6D (12), a two-input gate. The other input to U6D is from U145D (14), which are the positive-going front porch pulses. The front porch pulses at this point are at the television horizontal rate, since every other pulse has been inhibited at the input to U145D by the ÷2 counter. The horizontal sync pulse and the front porch pulse are combined in U6D to form the horizontal drive pulse at the output of U6D (14); see Fig. 3-5 K. The pulse is coupled through inverter U48E to the base of Q70B. The signal is coupled through the amplifier and appears at the connector on the rear panel as a negative-going pulse from approximately +0.6 V to −5 V in amplitude.

The composite blanking signal out is developed by the pulse from the horizontal blanking multi and the pulse from pin 9 of J-K flip flop U39B (see Fig. 3-6 L). The signal on pin 9 of U39B is of the same time duration as the vertical blanking interval. Pin 9 of U39B is coupled to U147A (14), a three-input gate. The output of the horizontal blanking multi is coupled to U147A (2) and the other input to the gate is from the External Composite Blanking In circuit. With no external signals in, U147A (1) remains in the 0 state. During vertical blanking time, U147A (14) will be in the 1 state and the output of the gate in the 0 state. At the completion of the vertical blanking pulse, U147A (14) goes to the 0 state and the output of the gate (pin 3) inverts and follows the horizontal blanking multi output. The signal at U147A (3) is coupled through two inverters, U48A and U76D, to the base of Q62B. The composite blanking signal is then coupled through two amplifiers, Q62B and Q158, to the Composite Blanking Output connector on the rear panel of the instrument. This signal meets EIA Timing specifications.

The composite blanking signal on the output of inverter U48A (1) is also coupled to U147B (13), a three-input gate. The other two inputs to the gate are from the Erase Gate Interval switch, which is a program function, and the WRITE ONLY position of the WRITE ONLY, WRITE AND READ, READ ONLY switch. As previously explained, with neither write only nor erase gate interval selected, the respective inputs to the gate will be in the 0 state. Therefore, the composite blanking signal will be coupled through and inverted by U147B. The signal is then coupled to the base of Q102B, which couples it to the Read Amplifier circuit, where it is used as the read amplifier gate.

The blanking ears, which are developed in the Read Raster circuit and coupled to the Z Axis Amplifier, are developed from the switch gate pulse and the composite blanking signal. The composite blanking signal at U76D (5) is coupled to U147C (6), a three input gate (see Fig. 3-10 A). The output of the switch gate multi is coupled to U147C (7), Fig. 3-10 B. The other input, U147C (8), is connected to the WRITE ONLY position of the WRITE ONLY, WRITE AND READ, READ ONLY switch and receives an inhibit signal when the switch is in the WRITE ONLY position. The output of the gate, U147C (5) (see Fig. 3-10 C) is coupled to U145C (10). The other input to U145C is connected to the erase gate interval switch and receives an inhibit signal when the switch is actuated. Since the switch is not actuated, the blanking ears are coupled through U145C and appear as a negative-going signal on the

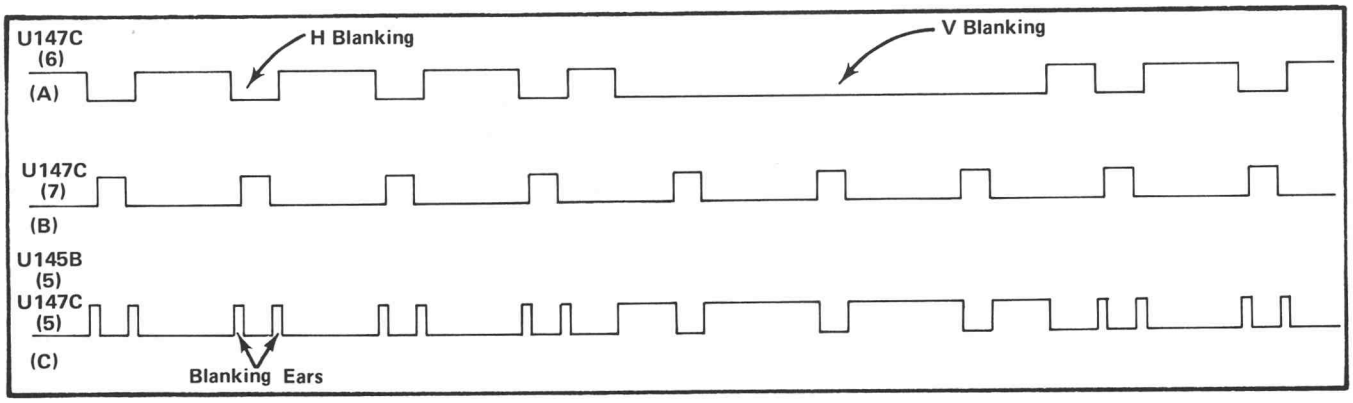


Fig. 3-10. Waveforms illustrating the inputs and output of U147C.

base of Q175. The blanking ears are coupled through Q175 to the Z Axis Amplifier circuit.

The signal at U145C (8) is also coupled to U145B (7), another two-input gate, which also has its other input connected to the erase gate interval switch. Since no inhibit signal is being received at U145B (6), the blanking ears are coupled through the gate and appear at U145B (5) in the same polarity as at U147C (5). The output of U145B (5) is coupled to the input of inverter U48D (10). The signal is inverted by U48D and appears at the anode of CR101 as a negative-going signal, (Fig. 3-11 A). CR100, CR101, and Q102A form a NOR gate to develop the Read Amplifier clamp. The signal on the anode of CR100 is a positive-going H Drive pulse (Fig. 3-11 B). Q102A is turned off if either of the two diodes is forward biased and the output of the gate (collector of Q102A) is in the 0 state. By referring to Fig. 3-11 A and B it can be determined that the inputs to the gate are in the 1 state except during the time of the second blanking ear. During the time of the second blanking ear the diodes are reverse biased, the transistor is turned on and the Read Amplifier clamp is developed (see Fig. 3-11). When the erase gate interval or write only functions are selected, the output of U145B (5) goes to the 0 state, producing a 1 at the output of the inverter, U48D (5). CR100 is reverse biased at this time and prevents the H drive pulse from being inhibited.

External Signals In

There are provisions for external composite sync and composite blanking signals to be coupled into the Read Raster circuit. When external signals are coupled into the circuit, both composite sync and composite blanking must be coupled in at the same time for the Read Raster circuitry to function correctly.

The composite blanking signal is coupled to the base of U3D from J131, External Composite Blanking In. The negative-going composite blanking signal on the emitter of U3D is coupled through an inverter (U76E) to the base of Q140 through CR140. The diode is normally reverse biased and the positive-going blanking pulse causes it to become forward biased. During the time the diode is turned on, C140 charges in the positive direction. During the time the

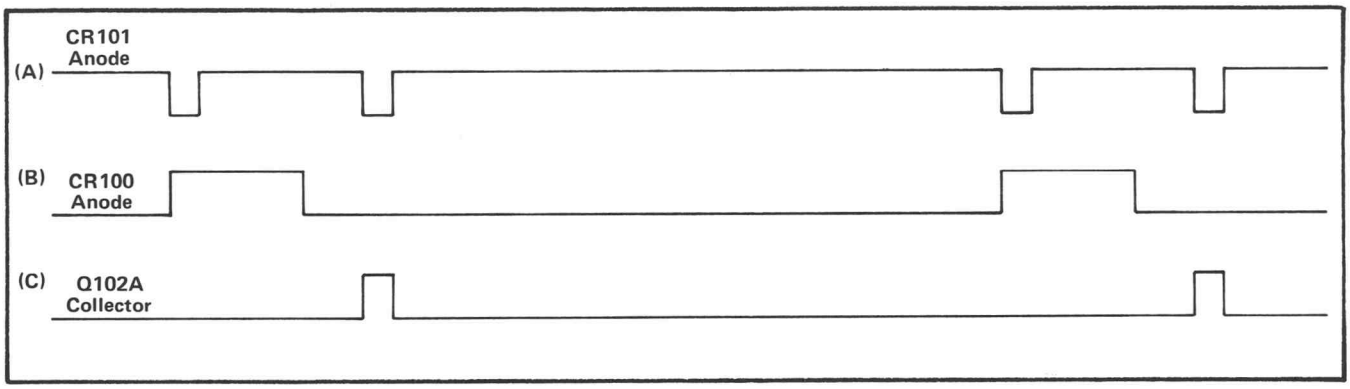


Fig. 3-11. Time relationship of waveforms used to develop the Read Amp clamp.

diode is off, C140 discharges through R140 and R141. The discharge time constant is sufficiently long that the charge on the capacitor keeps the transistor turned on between blanking pulses. Therefore, Q140 is on during the entire time an external blanking signal is coupled to the base of U3D. The collector of Q140 is therefore held in the 0 state during the time an external composite blanking signal is coupled into the Read Raster circuit.

The composite blanking signal on pin 6 of U76E is also coupled to U145A (2), a two-input gate. The other input to U145A is from the collector of Q140. Since U145A (1) remains in the 0 state, the gate acts as an inverter to the composite blanking signal. Appearing at U145A (3) is a negative-going composite blanking signal, which is coupled to U6B (7). The other input to U6B is from a flip flop consisting of U8B and U9B. The signal on pin 6 of U76E is differentiated by C136/R136 and coupled to the input of flip flop U8B (6), and the positive-going pulses trigger the flip flop. The time duration of the multi, which is established by C138 and R138 is approximately 12 μs. Appearing at the output of the flip flop are positive-going pulses that occur at the same time as the blanking pulses and extend for 12 μs. The output of the flip flop is coupled to U6B (6). The inputs to U6B are the composite blanking signal at U6B (7) and the output of the flip flop at U6B (6); see Fig. 3-12 A and B. The output of the gate, U6B (5), is in the 0 state, except during vertical blanking at which time it assumes the 1 state (see Fig. 3-12 C). The output signal of U6B is inverted by U5C and coupled to U39A (12) and U43B (7). Therefore, except during vertical blanking, the ÷2 counter and the vertical offset pulses are inhibited. During vertical blanking these two circuits are released to trigger the multis, which develop the signal used in the Type 4501 (such as blanking ears, read amp clamp, etc.). Without this provision these signals would not be developed during vertical blanking time with external signals in.

The signal on the collector of Q140 is also coupled to an inverter, U76F. Since the collector of Q140 remains in the 0 state with an external signal applied, the output of the inverter, U76F (7) remains in the 1 state. The output of U76F (7) is coupled to U46C (6) and inhibits the composite sync signal, developed in the Read Raster circuit, from being coupled through U46C. The output of U76F is also coupled to U39B (7). A 1 on U39B (7) causes U39B (9) to go to the 0 state and remain in that condition as long as the 1 is applied to pin 7. The output of U39B (9) is coupled to U147A (14), three input gate. The other two inputs to the gate are from the horizontal blanking multi to U147A (2) and the composite blanking signal from pin 6 of U76E to U147A (1). The output of the horizontal blanking multi occurs at the same time as the blanking pulses in the composite signal and both signals are of the same polarity at the input to the gate. Therefore, the composite blanking signal appears at the output of the gate, U147A (3).

The blanking pulses in the composite blanking signal at pin 6 of U76E are differentiated by C134 and R135 and coupled to U92B (6). Since the other input to U92B is in the 0 state, as previously explained, the differentiated signal is inverted by U92B and coupled to U5F (8). U5F inverts the signal and appearing at U5F (7) is a positive-going spike that is coincident with the leading edge of the blanking pulse in the composite blanking waveform. This positive-going pulse is used to trigger the front porch, switch delay, and horizontal blanking flip flops.

The External Composite Sync In is coupled from J1 to the base of U3C, an emitter follower. The negative-going signal is coupled through U5A, an inverter, to U6C (9). U6C (10) is held in the 0 state by the output of U46C, as previously explained in the external composite blanking description. Therefore, the composite sync signal is inverted by U6C and appears as a negative-going signal at U6C (8). The remaining sequence of events was explained under the subtitle Output Signals.

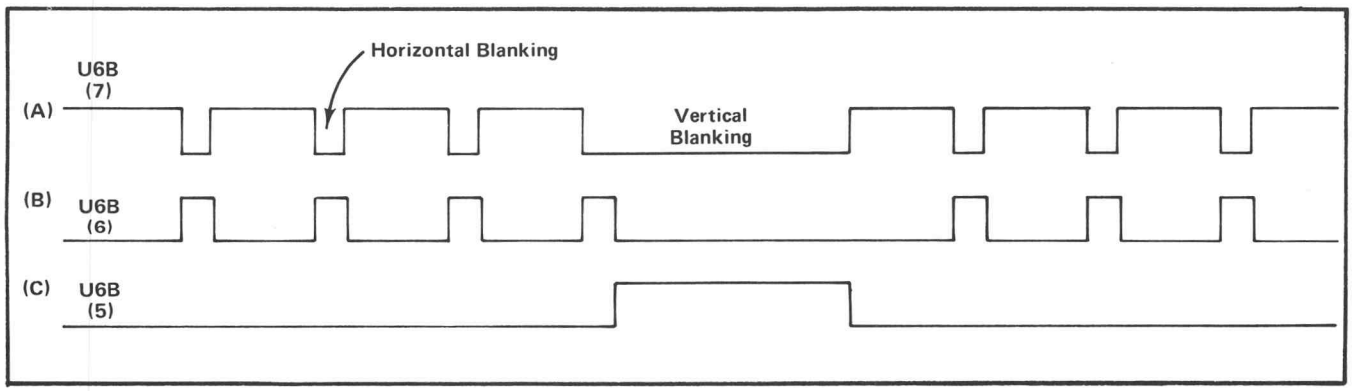


Fig. 3-12. Waveforms illustrating the inputs and output of U6B during External Signal In operation.

The signal on the emitter of U3C is also coupled to U6A (2). The other input to U6A is from the flip flop consisting of U8A and U9A. The flip flop is triggered by the positive-going sync pulses in the composite sync signal. The output of the flip flop, U9A (1), is positive-going pulses approximately 5 µs in duration. The time constant for the multi is determined by C8 and R8. The two input waveforms to U6A and the output waveform appearing at U6A (3) are illustrated in Fig. 3-13. The output waveform at U6A (3) is coupled to U70A (2). The other input to U70A is from the flip flop consisting of U45A and U44C. Since U39B (9) is locked in the 0 state, the output of the flip flop, U44C (5) also remains in the 0 state. Therefore, the signal from U6A (3) is inverted by the gate and coupled through inverter U76B to the vertical ramp circuit. The vertical ramp timing capacitor is discharged by the positive-going pulses occurring during the vertical pulse time.

625 Line Operation

When the 525/625 switch is placed in the 625 position, the logical 0 that was connected to the cathode of CR14 (through the switch) is removed and a logical 1 is now connected to the cathode. This reverse biases CR14 and allows the 31.25 kHz crystal (Y13) to oscillate. The logical 1 is also connected to U48F (8), an inverter. This causes U48F (7) to go to the 0 state, placing a ground on the cathode of CR18 through the inverter. The diode is now forward biased, which effectively grounds the feedback to the 31.5 kHz crystal (Y17) and prevents the crystal from oscillating. The output frequency of the oscillator has now been changed to correspond to 625 line operation.

Since U48F (7) is now in the 0 state, the inhibit signal previously applied to U90A/B and U44A has been removed. The logic for these gates, plus the logic for U41A/B and U45A must now be taken into consideration in the development of the vertical interval pulse. Also with the switch in the 625 position, the preset pulse which occurs at binary count 512 is removed from counters 16, 32, and 64. The preset pulse is now connected to counters 4 and 8, producing count 911 when preset occurs. The purpose of changing the logic for 625 line operation is to develop five equalizing pulses and five serrations during the vertical interval instead of six equalizing pulses and six serrations, which are used in 525 line operation.

Z AXIS AMPLIFIER

General

The Z Axis Amplifier controls the storage CRT beam current as appropriate to the needs of the write and read functions. During read time, the Z Axis output is set at a fixed level (approximately +17 V). During write time, the Z Axis output level is determined by the Write INTENSITY control in conjunction with the external signal that is connected to the Z axis input connectors. The signal required to turn the CRT beam current from off to full on is approximately 1 volt. The Write INTENSITY control allows the 1 volt range to be offset at least from −1 V to +1 volt. The Gain control provides a means of varying the nominal 1 volt sensitivity by ±50% (0.5 V to 1.5 V).

The Write signal amplifier (Q220A, Q220B, and U245) is differential in both Linear and Limiting modes. The Limiter is active even in Linear mode, and its output is brought off the board for possible use to drive a Write Only command switch.

Read-Write switching is handled by dual channel amplifier U275. The Write signal is applied to inputs 3 and 4, Read level goes to pin 6, and blanking ears go to pin 5. Switching logic drives pin 2. In Write mode, pin 2 is at about −5 volts; in Read mode pin 2 is about +4 volts.

The difference signal between +Z and −Z inputs is amplified by approximately 40 at the Z output (pin S). From the output of U275 to pin S, the double-ended to

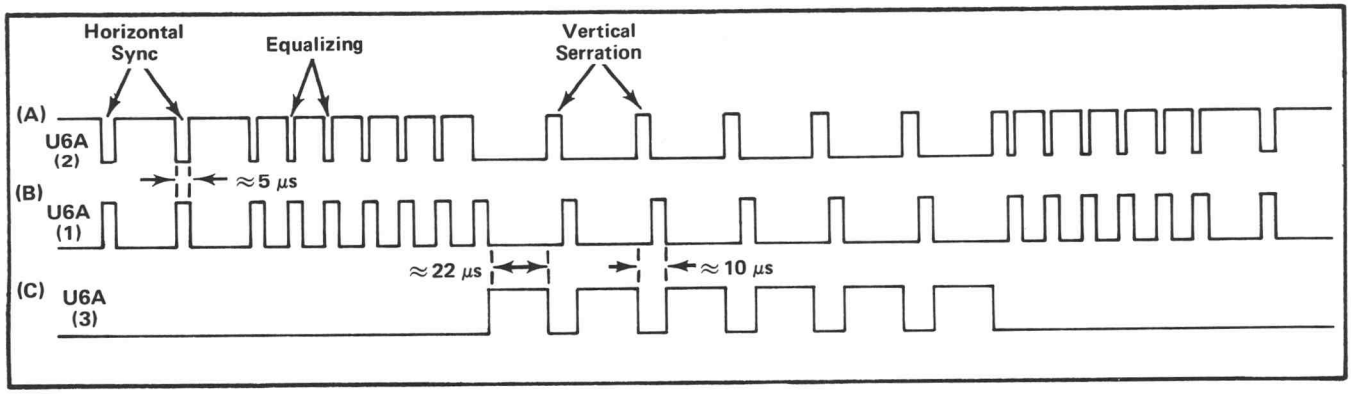


Fig. 3-13. Waveforms illustrating the inputs and output of U6A during External Signal In operation.

single-ended gain is 32. Over all gain is calibrated by the variable Gain adjustment.

In Limiting mode, U275 receives the output of U245. When there is no +Z or −Z input, pin 7 of U245 is held in its high state by current through R242. The high state is limited to about +1.5 V by diodes CR258 and CR260 and then attenuated to 0.5 V at pin 3 of U275. This is enough signal to keep the Z Axis output at approximately −7 V at any setting of the INTENSITY control.

The output of U245 remains in its high state until input signal(s) cause the +Z input to approach one volt positive with respect to the −Z input. The positive feedback resistor (R249) causes U245 to flip to its low state when the difference between pins 2 and 3 reaches about 5 mV. The low state is between zero and −1 volt. This state is then level-shifted to zero volts and mixed with the INTENSITY control voltage at pin 3 of U275. The Z output at pin S can then be set by the INTENSITY control anywhere between −7 volts and +50 volts. Input signals exceeding one volt cannot drive pin 3 of U275 any further negative and cannot change the Z axis output voltage determined by the INTENSITY control setting. Maximum input signal for Limiting operation is ±15 V on either +Z or −Z input. Maximum non-destructive voltage is ±200 volts.

The common-mode output voltage of U275 (pins 1 and 7) is not tightly controlled. This common-mode voltage is applied to the inputs of Q295A and Q295B. Outputs from the emitter of Q295A and Q295B are applied to the base of Q285B. The voltage at the base of Q285B is compared with the reference voltage at the base of Q285A. The resulting signal at the collector of Q285B is applied to pin 9 of U275 and thereby controls the common-mode voltage at pins 1 and 7 of U275.

CRT READ Current Regulator

CRT beam current is held at a pre-set value during Read time by a regulator amplifier. A proportional measurement of the current is obtained by measuring the current being intercepted at the limiting aperture in the second anode of the gun. This is the electrode (pin 8 of the CRT) used to control astigmatism. Q385, U390, and Q365 are connected in an operational loop. The gate of Q385A is the summing junction for this amplifier. The amplifier floats at a DC voltage of approximately +120 volts as determined by the setting of the Astigmatism adjustment. Power is supplied by Q370 and Q378, and the supply voltage to Q385 and U390 is fixed at 18 volts by VR375 and VR376.

When the CRT beam is cut off, the output of the operational loop at Q365 emitter is held at the center of the 18 volt supply voltage. This is equal to the voltage at the junction of VR375 and VR376. The voltage drop across R365 is 9 volts which creates 1 mA collector current in Q365. When the beam is turned on to normal read current level, about 1 μA of current is collected by the astigmatism electrode. The operational loop sees a negative current into its summing junction, reacts by supplying an equal but opposite current from its output (Q365 emitter) through R366. Sensitivity of the amplifier loop is 200 mV/μA. At Q365 collector, a signal of 100 mV/μA is developed.

Transistor Q358 is turned OFF during Write time so that the memory capacitor (C358) remains charged to the approximate +5 V level established by the read current. Q348 compares the memory voltage with the reference voltage at R341 and amplifies the difference at U345, pin 6 (TP346). The signal at TP346 is the read level input to the Z axis amplifier. Any change in read current is thus immediately corrected by a change in CRT grid drive. Diode CR346 limits the positive swing of the error signal when the memory discharges during long periods in WRITE ONLY.

X-Y AMPLIFIERS

General

External signals are coupled to the horizontal and vertical deflection plates of the storage CRT through the X (horizontal) and Y (vertical) input amplifiers. The horizontal and vertical ramps, which are occurring at the television rate and are used to scan the written area so it can be displayed on television monitors, are also coupled into the X-Y Amplifiers. The input signal or writing signal and the ramps are time-shared and controlled by a switching signal.

Differential Input

Except for circuit numbers, the differential input circuits for the X and Y amplifiers are identical to the input circuitry of the Z Axis Amplifier. Therefore, refer to the Differential Amplifier circuit description for the Z Axis Amplifier for a detailed description of the differential amplifier circuits. The vertical and horizontal POSITION controls function in the same manner as described for the Write Intensity control in the Z Axis Amplifier description.

Diode Switching

Except for circuit numbers, signal polarity and timing, the X and Y amplifiers are identical; therefore, only the X amplifier will be described in detail.

The signal from emitter follower Q455 is coupled to a diode switching circuit consisting of CR456A/B, CR457, CR458A/B, and CR459. Fig. 3-14 illustrates the time relationship of the signals applied to the switching circuit. During the positive-going portion of the switching signal

applied to the cathode of CR459 (Fig. 3-14A) the diode is reverse biased and diodes CR456A/B, are forward biased through R456 to +15 V. This allows the write signal to be coupled to the base of Q460B. During this same time a negative-going switching signal, Fig. 3-14B, is applied to the cathode of CR457 which forward biases the diode and reverse biases CR458A/B. This inhibits the horizontal ramp, which is applied to the cathode of CR458A, from being coupled to the base of Q460B during write time. When the positive-going pulse on the cathode of CR459 goes in the negative direction, the diode is forward biased and CR456A/B are reverse biased. At this same time, the switching signal on the cathode of CR457 goes positive, which reverse biases CR457. CR458A/B becomes forward biased, coupling the horizontal ramp to the base of Q460B.

Output Amplifier

The signal from the diode switching circuit is coupled to the base of Q460B. Transistors Q460A/B are connected in a differential configuration with a push-pull output. Assume a positive-going signal on the base of Q460B. This develops a negative-going signal in the collector circuit. The positive-going signal on the base is also emitter-coupled to the emitter of Q460A, and a positive-going signal is developed in the collector circuit of Q460A. R460 also couples part of the signal on the base of Q460B to the emitter of Q460A. This produces equal gain from Q460A/B. The gain of the X Amplifier is set by the adjustment of R462 in the emitter circuit of Q460A/B. The signal on the collectors of Q460A/B is coupled through three more stages of differential amplification to the output stage, consisting of Q490 and Q495. The signal on the emitter of Q478/Q488 is fed back through R475/R485 to the emitters of Q460A/B, producing a constant current through the differential amplifiers. This insures a constant current through the output transistors, Q490/Q495. Q490/Q495 are grounded base transistors connected in a differential configuration. The push-pull output from Q490/Q495 is developed across L490, R492, L492, L497, R497, and L495. The signal to the right deflection plate is taken off the center tap of L490 and the left deflection plate signal is obtained at the center tap of L495. Resistors R479/R489 are connected to −15 V to insure that Q490/Q495 are never cut off. Capacitors C461, C483, C487 and resistors R474/R477 are peaking adjustments.

Neon lights DS490/DS495 are provided to indicate the relative position of the writing dot if it is off screen, in the WRITE ONLY mode of operation. When the write only mode is selected, the raster is inhibited and the write signal is coupled through the amplifier. If the amplifier is unbalanced to such an extent that the writing dot is off screen, the neon connected to the deflection plate with the highest potential will turn on.

STORAGE CIRCUIT

General

The Storage Circuit provides the voltage level necessary to operate the flood guns and the collimation electrodes of the storage CRT. The storage circuit generates an erase pulse to erase the written information. This pulse is manually controlled. During the erase cycle, a negative-going pulse of the same time duration as the complete erase cycle is produced by the erase interval circuit. This pulse can be used to notify associated equipment that the scan conversion storage unit is being erased. An Integrate circuit is also provided on the Storage board which shuts off the flood gun current if the integrate function is used. The basic operation of the storage CRT is described at the beginning of this section.

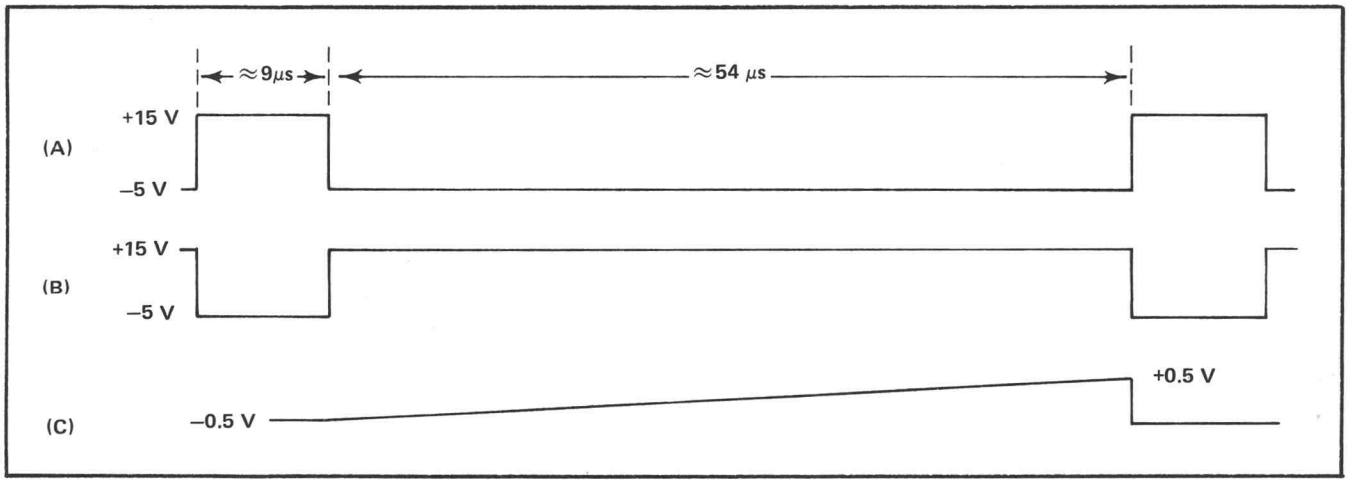


Fig. 3-14. (A) Switching waveform present on cathodes of CR459 and CR559. (B) Switching waveform presents on cathodes of CR457/ and CR557. (C) H ramp present on cathode of CR458A.

Flood Guns and Collimation Electrodes

The flood guns are low-energy guns which direct a large area flow, or cone, of electrons toward the entire screen. The collimation electrodes shape the flood spray for uniform coverage of the storage target. The operating level of the tube is the potential difference between the target backplate and the flood gun cathodes. The collimation electrodes have no effect on the bombarding energy of the flood gun electrons.

The flood gun cathodes are connected through Q678 to the +3.75 V supply. Q678 is normally on unless the Remote Integrate switch is depressed. When the Remote Integrate switch is depressed, the base of Q678 is pulled down to approximately +0.6 V and the transistor is turned off, opening the CRT cathode circuit and turning off the flood gun current. Diode CR678 isolates the base of Q678 from the remote program line, thereby preventing any positive voltage that may be present on the program line from being applied to the base of the transistor.

The flood gun bias is adjusted by R692 which sets the negative voltage on the flood gun grid. The bias is adjustable from 0 V to approximately −50 V. The voltage on the flood gun anode is determined by R690, which is connected through zener diode VR690 to +200 V. Uniform coverage of the storage CRT is achieved by adjusting R682 and R687 which control the DC potential applied to the collimation electrodes.

Erase Cycle

During the following circuit description, it may be helpful to refer first to Fig. 3-15, a detailed block diagram of the circuit used to develop the erase pulse that is applied to the CRT target. Fig. 3-16 illustrates the waveforms at various points in the circuit. The letter appearing by each waveform has a corresponding letter on the block diagram identifying the point where the waveform appears.

When the erase button is depressed, a ground is applied to the cathode of CR602 or CR603. This turns the diode on and applies a negative-going pulse to pin 14 of U610A. At the output of U610A (pin 1) is a positive-going pulse which is coupled through C612 to the input of U610B. U610B and U610C are connected in a monostable multi configuration, and the positive-going pulse causes the multi to flip. The timing capacitor and resistor for the multi are C614/R614, and the time duration of the output pulse is 10 ms. The output of U610C is normally low; therefore, when the multi changes states a positive-going pulse appears on the output of U610C and a negative-going pulse appears on the output of U610B. The negative-going pulse on the output of U610B differentiated by C615 and coupled to the input of U610D. U610D and U610E are connected in a monostable multi configuration with the output of U610E normally low. The timing capacitor and resistor for this multi are C618/R618. The positive-going (trailing edge) pulse of the differentiated waveform causes the multi to change states, which develops a positive-going pulse on the output of U610E and a negative-going pulse on the output of U610D. The time duration of the pulse is 40 ms and it is delayed 10 ms (by U610B/C) from the time the erase button is depressed.

Before proceeding, examine conditions in part of the remaining circuitry. Q650 is on; therefore, its collector is pulled down, keeping CR654/CR653 reverse biased and Q655 off. Q630 is off, so its collector is negative, turning on Q640 and Q642, and causing their collectors to be positive. The Store level adjustment and the Non-Store level adjustment are in the collector circuit of Q642. Assume the Type 4501 is being operated in the store mode. The store level will be coupled through CR655 to C655, and the capacitor will charge to the store level. This level will also be coupled through CR656/CR659 and appear at pin 2 of U660. C655 will maintain a stable level at this point. Now as the output of U610D goes negative, Q650 is turned off and its collector goes in the positive direction. CR653/CR654 becomes forward biased and Q655 turns on. With CR654 forward biased and Q655 turned on, the positive rise on the collector of Q650 is limited to two diode drops (1.2 V) above the level on C655. This positive-going pulse is coupled through CR653/CR659 to pin 2 of U660. The negative-going pulse on pin 5 of U610D is also coupled through R630/C630 to the base of Q630, turning the transistor on. When Q630 turns on, its collector becomes positive and turns off Q640/Q642. C635, which is connected from the emitter to the collector of Q630, now discharges through the transistor. Since Q642 is turned off, its collector is at ground potential or 0 V. This sets the anodes of CR655/CR656 at 0 V, and the diodes are reverse biased. As the pulse on the base of Q650 goes positive, Q650 turns on, turning Q655 off. The pulse on pin 2 of U660 starts negative and is pulled down to ground by CR656 becoming forward biased. When the base of Q650 goes positive, the base of Q630 also goes positive and Q630 turns off. With Q630 off, C635 starts to charge through R634, R636, and R637, turning on Q642. The voltage at the junction of CR655/CR656 starts to ramp up and this ramp is coupled through CR656/CR659 to pin 2 of U660. C635 will continue to charge until Q642 is fully on. At the completion of the ramp, the voltage at pin 2 of U660 is at the level set by the Store adjustment. Pin 2 will remain at this level until the ERASE button is pressed again. The complete erase cycle is illustrated in Fig. 3-16E.

Integrated circuit U660 and transistors Q665 and Q675 are connected in a feedback amplifier configuration. The gain of the stage is determined by resistors R673, R674, R675 and capacitor C674. The signal (erase pulse) is coupled through U660, Q665 and emitter follower Q675, to the CRT target via the Read Amplifier. The target is completely written by the positive-going portion of the

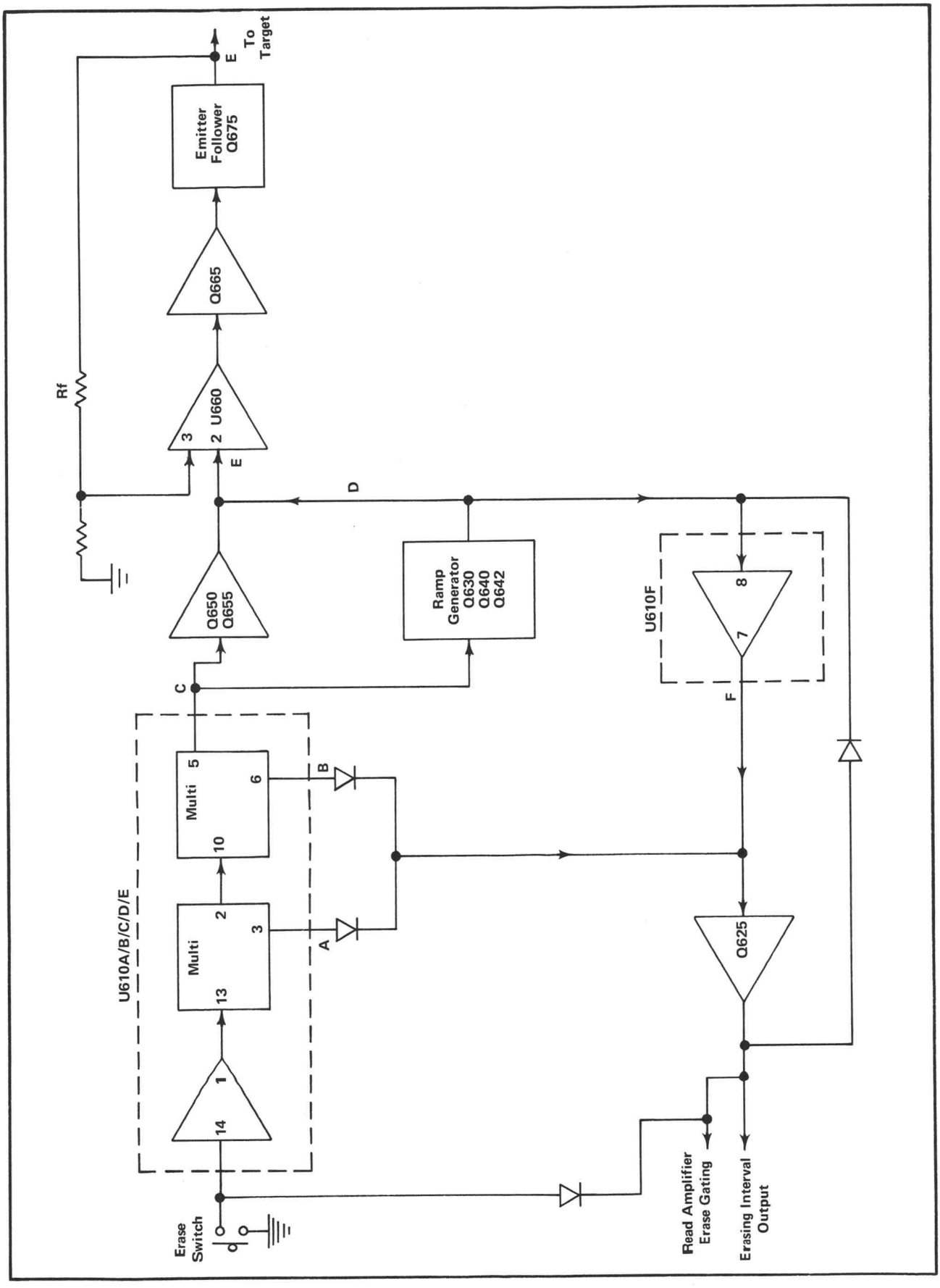


Fig. 3-15. Detailed block diagram of the erase cycle circuitry.

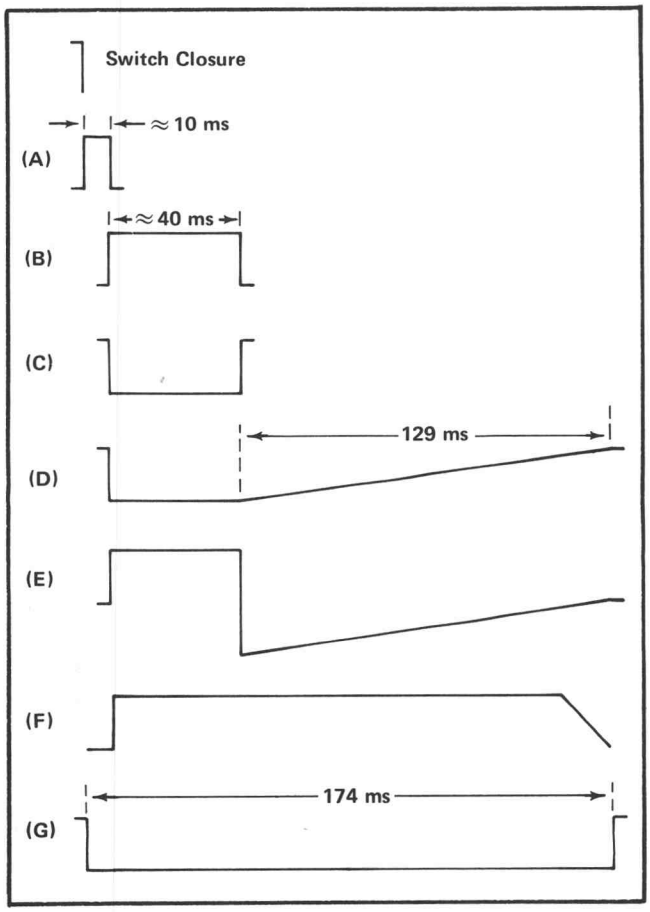


Fig. 3-16. Time relationship of the waveforms present in the erase cycle circuit.

erase pulse; next the target is pulled to a very low potential by the trailing edge of the 40 ms pulse, which erases the target, and then it is slowly returned to its operating level by the ramp. Diode CR672 is a protection diode that prevents reverse base-emitter breakdown of Q675. The circuit voltage at the output of U660 is limited to +15 V and −15 V by protection diodes CR663/CR664. The feedback which is applied to pin 3, the + input, of U660 is of the same polarity as the input signal applied to the −input (pin 2); thus it is negative feedback.

The storage target backplate level on the emitter of Q675 is also coupled to the base of Q680 through the center arm of R682. The adjustment of R682 controls the voltage level on CE-2. Since the voltage across R682 will change according to the backplate level, the voltage on CE-2 will also be governed by the backplate level, providing uniform luminance at all STB levels.

During the time of the fade positive pulse, (the time during the erase cycle when the storage target is being fully written) the CRT flood gun cathode is pulled to approximately −50 V. The negative-going pulse at pin 5 of U610D is coupled to the base of Q615, causing the transistor to saturate. As Q615 turns on, it causes Q670 to saturate, putting −50 V on the cathode of the CRT through the transistor. The cathode is normally operating at approximately +3.75 V through transistor Q678. During the time Q670 is on, CR670 is reverse biased and Q678 is off.

The STB Level for store and non-store are different, and the level selected depends on the position of the Store/Non-Store switch which controls a reed switch, K645. The store level adjust is connected to the normally closed contact of the reed switch. When the non-store function is selected, a ground is connected to the cathode of CR648 or CR649. This causes the base of Q645 to go negative and the transistor turns on. Current for the transistor flows through the coil of the reed switch, energizing K645 and selecting the non-store level adjust.

During the time the CRT is being erased, a negative-going pulse is developed with a time duration of 174 ms ocurring at the same time as the erase cycle. This pulse is coupled to the Read Raster circuit, and develops another pulse that gates the Read Amplifier off during erase time; it can also be used to notify auxiliary equipment that the Scan Conversion Storage Unit is being erased.

The erasing interval pulse is developed in the collector circuit of Q625. The positive-going 10 ms pulse at pin 3 of U610C (Fig. 3-16A) is coupled to the base of Q625 through CR624. The 40 ms positive-going pulse on pin 6 (Fig. 3-16B) of U610E is coupled through CR625 to the base of Q625. Q640 is turned off by the leading edge of the negative-going pulse at pin 5 of U610D (Fig. 3-16C) so its collector is at 0 V. As C635 starts to charge, Q640 is held off by zener diode VR639 until the ramp approaches approximately 5 V; then, Q640 turns on. The collector signal of Q640 is level-shifted by VR641 and coupled to pin 8 of U610F. The signal is inverted by U610F and coupled through CR622 to the base of Q625 (Fig. 3-16F). Thus, three positive-going signals with a total time duration of 200 ms appear at the base of Q625. These signals are time-related as illustrated by waveforms A, B, and F of Fig. 3-16. The signals on the base of Q625 are of sufficient amplitude to saturate the transistor, so the collector of Q625 is pulled down, coincident with the leading edge of the 10 ms pulse, and remains down until the completion of the ramp. At the completion of the ramp, the collector of Q625 starts to go positive, this positive-going signal is coupled through CR621 to the input (pin 8) of U610F, which inverts the signal and reverse biases CR622. This turns off Q625 very fast to square up the trailing edge of the erasing interval pulse. The waveform appearing on the collector of Q625 is a negative-going pulse, approximately 174 ms in duration (see waveform G of Fig. 3-16), which is coupled to the Read Raster circuit and the remote program connector. The negative-going pulse on the collector of Q625 is also

coupled through CR620 to the input of U610A. Thus, any switch bounce produced by the Erase switch is eliminated at the input of the erase cycle circuitry. The amplitude of the gating pulse to the Read Raster circuit is from +15 V to 0 V. The amplitude of the erasing interval output pulse to the remote program connector is from +10 V to 0 V which is determined by the divider consisting of R628/R629. CR628 isolates the divider from the Read Amplifier gating pulse.

READ AMPLIFIER

General

The stored display is coupled from the CRT target through the Read Amplifier, and can be used to drive remote television monitors. The signal is available at J1280 as composite video or at J915 as a video modulated carrier. The carrier frequency is tunable from approximately 54 MHz through 72 MHz, which corresponds to U.S. television channels 2, 3 and 4.

Secondary electrons are produced when the CRT target is scanned by the reading beam. It is in the collection of these secondaries that a readout signal current is developed in the STB supply lead. When non-written areas are being struck, nearly enough secondaries are collected by the wall bands to offset the incident beam current. A small negative "pedestal" signal is developed. When written areas are being struck, most of the secondaries fall back on the target surface and the backplate. A much larger negative signal current is developed. The read amplifier senses the current variations, amplifies and processes the video, and assembles a composite TV picture signal.

The polarity of the output signal from the Read Amplifier is selectable as either a positive or negative video signal. This permits the signal to be viewed on the monitors as either a dark signal on a light background, or a light signal on a dark background.

The Read Amplifier Circuitry can be best described by identifying the distinctive functions which are required to produce the final TV picture signal. Control signals needed for processing functions are brought to the Read Amplifier from other places in the 4501, and fed into the appropriate stages. Fig. 3-17 is a simplified block diagram of the Read Amplifier.

Pre-Amplifier. Q705, Q710, U715 and U730 form the pre-amplifier stage. A 1 μA (P-P) signal at Q710 emitter produces 1 mV (P-P) at Q710 collector; 10 mV (P-P) at U715, pin 10; and 500 mV (P-P) each at U730, pins 6 and 7. The gain of each sub-stage is stabilized by local feedback to allow tandem connection without overall signal feedback around the loop. U730 is a linear IC amplifier with differential inputs and push-pull outputs. Pin 2, one of its inputs, is biased at +8 volts. Pin 1, its other input, is brought to the same operating voltage by the action of amplified DC feedback around the entire pre-amplifier loop. U730 outputs, pins 6 and 7, are connected by two resistor dividers to a differential pair in U715, pins 2 and 4. C736 and C732 serve to suppress video signals and allow only slowly-varying DC error signals to be amplified. If the DC voltages at U730 pins 6 and 7 are not equal, the error is amplified and applied to Q705 gate through Q732 in the proper phase to drive Q715 pin 10 to +8 V. Low frequency signal feedback is further suppressed by R708 and C706. CR708 and CR709 bypass R708 during large target excursions caused by the storage erase functions, and cause the amplifier to recover more quickly.

Target signals are coupled to Q705 emitter by the blocking capacitor, C703. C712, R713, and R712 boost the low frequency gain of Q710 to compensate the low frequency loss in C703. L725 attenuates the gain of U730 at frequencies above 20 MHz to reduce noise bandwidth in the pre-amplifier.

Externally generated marker signals can be added to the video through C704 and R705. Target shading corrections can also be added to the video through R784 and C784. These correction functions are generated on the Read Amplifier circuit board by U852, U875 and Q850.

Integrated circuits U875 and U852 with their associated circuitry form a shading compensation circuit to compensate for any storage CRT shading at the input of the Pre-Amplifier. U875 uses the horizontal ramp from the read raster circuit to develop the horizontal shading compensation function that is fed to the emitter of Q710, and U852 uses the vertical ramp from the read raster circuit to develop the vertical shading compensation which is also fed to the input of the amplifier. Except for circuit numbers and timing, the two circuits are the same; therefore, only U875, which utilizes the horizontal ramp, will be described in detail.

The positive-going ramp from the read raster circuit is coupled to the base of U875A. U875A/U875B are connected in a differential configuration and the signal on the base of U875A is the emitter coupled to U875B. The negative-going ramp on the collector of U875A is coupled through emitter follower U875D to the anode of CR878. The positive-going ramp on the collector of U875B is coupled through emitter follower U875C to the anode of CR880. The voltage on the cathodes of CR878 and CR880 is approximately +8 volts, and the diodes are biased so they only conduct on the most positive portion of the ramps on their anodes (see Fig. 3-18A and B). Fig. 3-18C illustrates the signal on the cathodes of CR878 and CR880. This signal is coupled through C876 to the base of U875E. The

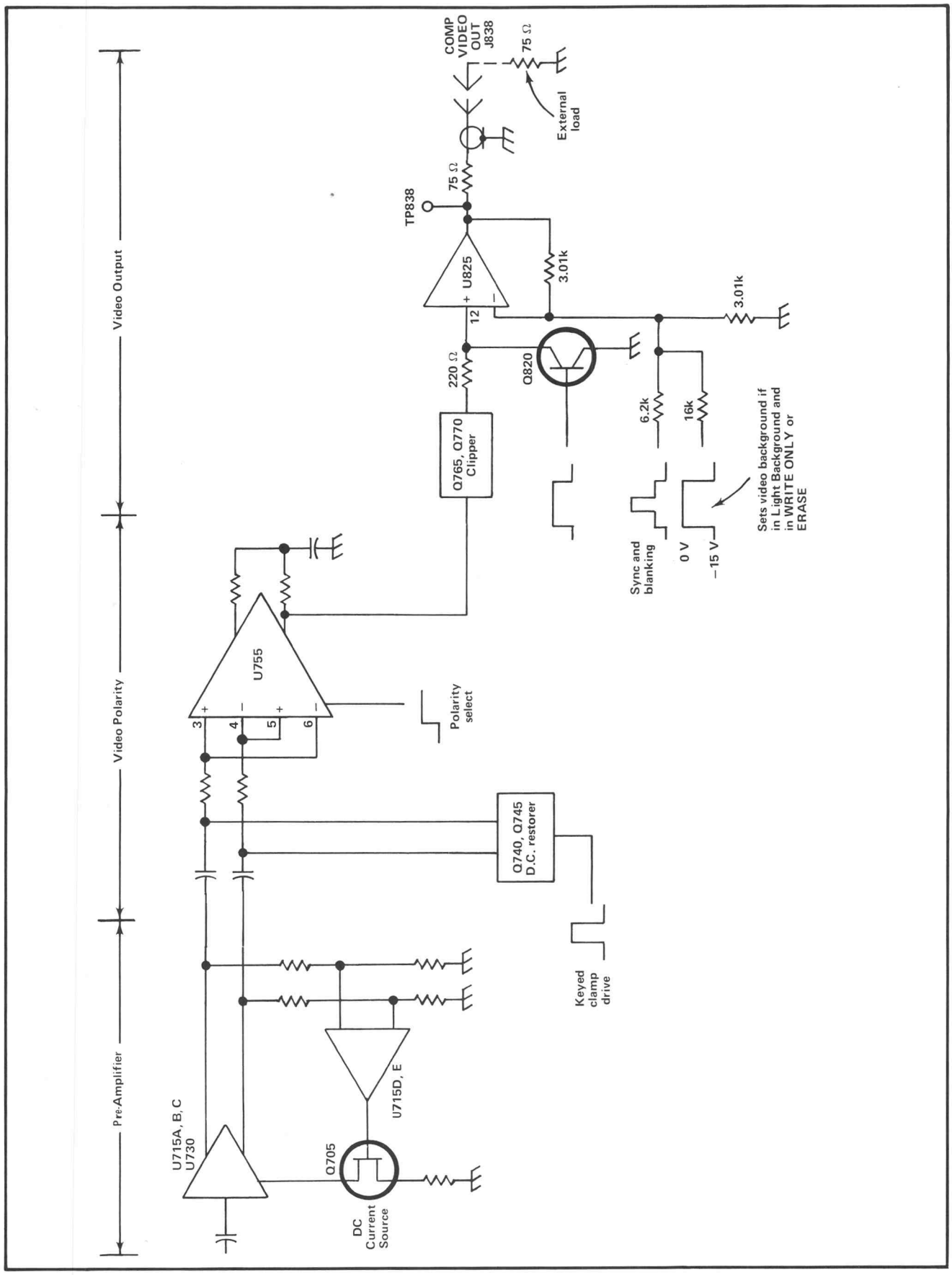


Fig. 3-17. Simplified Block Diagram of Read Amplifier.

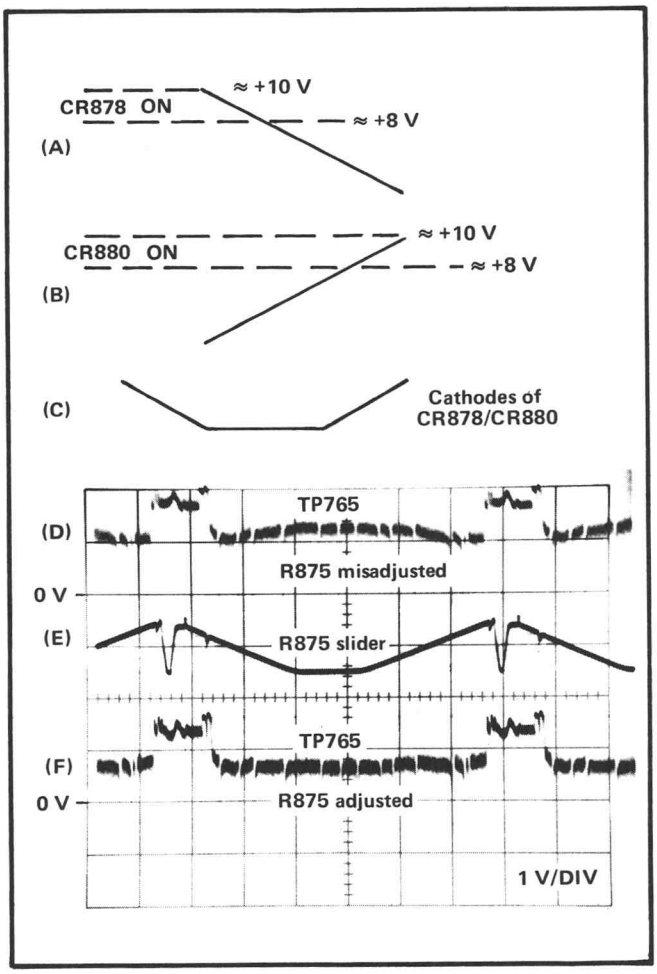


Fig. 3-18. A, B, and C illustrate the signal condition of CR878/CR880 and the resultant shading compensation waveform. D, E, and F illustrate the video signal, shading compensation signal and the resultant video signal.

signal on the emitter of U875E is coupled through C784 and R784 to the input of the pre-amplifier. R875 in the emitter circuit of U875E sets the amplitude of the horizontal shading compensation function. R885 in the base circuit of U875B sets the horizontal shading compensation centering. Fig. 3-18D is a typical waveform at TP765 with the Horizontal Shading Amplitude (R875) misadjusted. Figures 3-18E and 3-18F are waveforms taken with the Shading Amplitude (R875) properly adjusted. The waveform shown in Fig. 3-18E was taken at the movable contact of R875, and shows the corrective voltage being picked off. Comparision of Fig. 3-18F with 3-18D shows the effect at TP765 of proper adjustment of the Shading Amplitude.

In the non-store readout mode, the video pedestal is slightly lower in amplitude than in the Store mode. Q780 is turned off in non-store and allows a positive pulse of current to be added to the video through R783 and C783. Being coincident with the turn on of the keyed clamp DC restorer, the current pulse appears to increase the video pedestal amplitude. R782 may be adjusted to equalize store and non-store picture background.

DC Restorer and Video Polarity Selector. Q740 and Q745 are dual keyed clamp DC Restorers. They are turned on during the second Z axis blanking ear by the keyed clamp pulse from Q785 and Q790. Q750 presents a very high impedance to the video coupling capacitors C737 and C738 to prevent loss of DC reference during horizontal line time between clamp pulses.

U755 is a dual channel linear IC amplifier with differential inputs and push pull outputs. When pin 2 is released, input pins 5 and 6 are selected and the video output at pin 1 is positive for written areas. When Q815 is on and pulls pin 2 to ground, pins 3 and 4 are selected and the video output at pin 1 is negative for written areas. When pin 2 is pulled only part way down, the signals from both sets of inputs appear mixed at the output. Because these two sets of inputs are connected in opposition, the output signal is diminished. This is done during Write time to cancel the unwanted write-signal artifacts from the video. The appropriate voltage at pin 2 is developed by R798 (Cancel Balance), which sets the on current in Q795.

The video amplitude at pin 1 is approximately 1 V P-P. The absolute DC level of the video at pin 1 is critical, because the video clipper is driven from this point. The clipping window levels are +0.05 V and +0.08 V. Therefore, the video signal must be forced to swing about an average of +0.4 V. Because the signals at pins 7 and 1 are mirror images of each other, averaging the two in R764, R765, and C765 cancels the signal components and yields only the DC average of the two. This average is compared in Q760 with the 0.4 VDC set by R760 and R761. Q760B serves as a shunt regulator which varies the voltage supplied to pin 8, the negative supply for U755. The positive supply to pin 9 is kept 15 volts positive with respect to pin 8 by VR757. A change in average DC output level of U755 causes Q760 to change the average power supply voltages to U755 and restore the +0.4 V average at pin 1 (TP765).

The video clipping window voltage levels are established by Q770 and Q765. The DC level of the video is positioned in the window by R747 (Background Offset). Q770 is an emitter follower which cannot follow positive signals above the voltage set by R774 and R775. Q770 emitters drive Q765, which cannot follow negative signals below the voltage set by R767, R766, and CR767. Q765 emitters drive the non-inverting input of the composite video output amplifier U825. Q820 is turned on by U794C during TV blanking time, to provide a noise free period for addition of sync and blanking to the video.

U825 is an operational amplifier which has an amplification of two from its video input at pin 12 to its output at

pin 10. Pin 13 is the summing junction. VR833 drops the DC level of the output signal to near ground level at the time pin 12 is at ground. Sync and blanking waveforms from Q845 are added as current signals into the summing junction through R849.

During Write Only and Erase commands, pin 2 of U755 is held at the cancel level and Q820 is held on. The composite video output signal consists of the normal sync and blanking and a video portion that is a noise-free background level. In Dark Background the video amplitude is the black level established by the inverted blanking waveform from Q842 through R845, R848, and R849. In Light Background the video amplitude is raised to white level by turning off Q810 and allowing a current input through R812 and R183.

RF MODULATOR

The RF modulator circuit consists of U900 with its associated circuitry. The oscillator for the modulator circuit is U900E, which is connected in a Colpitts oscillator configuration. C937, C938 and L937 comprise the frequency-determining network for the oscillator. The carrier frequency of the oscillator is tunable from approximately 54 MHz through 72 MHz, which corresponds to U.S. television channels 2, 3, and 4. The Type 4501 is normally tuned to correspond to U.S. television channel 3, but can be tuned to channels 2 or 4 by the adjustment of L937. The oscillator frequency is coupled through C922 and drives U900D which is a current source for U900A/B. The composite video signal from the internal-external switching is coupled to the base of U900C through R901. U900C is an emitter follower and the signal on the emitter of U900C is coupled through C906 to the base of U900B. The composite video signal on the base of U900B is emitter coupled to the emitter of U900A and modulates the carrier frequency current going to the collectors of U900A/B. Appearing in the collector tank circuit of U900A is the RF-modulated composite video signal. The signal is transformer coupled to the secondary of T912. The signal is then coupled through R913 to J915, which is the modulated RF output connector on the rear panel of the Type 4501. C912 in the collector circuit of U900A tunes the tank circuit, and R912 which is connected across C912, is a swamping resistor. R915 in the base circuit of U900A sets the percentage of modulation of the output signal.

CRT CIRCUIT

General

The CRT circuit provides the voltage levels necessary for operation of the cathode-ray tube (CRT). The following controls are provided, as internal adjustments, to adjust the CRT for proper display: Intensity, Focus, Astigmatism, and Trace Rotation.

High Voltage Oscillator

The high voltage oscillator consists of Q1020 with its associated circuitry. The primary winding (pins 3 and 4) of T1020 is the tuned collector tank circuit; primary winding (pins 1 and 2) is the feedback winding to the emitter of the oscillator transistor. The frequency of the oscillator is approximately 40 kHz. L1022 and capacitor C1024 provide decoupling for the −50 V supply. C1022, in the base circuit of Q1020, is an AC ground.

When power is initially applied to the equipment, Q1015/Q1018 turn on and supply base drive to the oscillator. As current starts to flow through Q1020 and its collector winding, a voltage is induced into the feedback winding which turns the transistor on more heavily driving Q1020 into saturation. Since the current through the collector winding is no longer changing, the voltage induced in the feedback winding starts to collapse. Q1020 begins to turn off. The flux in the core diminishes and induces a voltage into the feedback winding which reinforces the transistor turn off. After the field around the collector winding has collapsed, the current through the transistor starts to increase again and the cycle starts over.

The high voltage developed by the oscillator is induced into the secondary windings, pins 5 and 8, which supply the CRT cathode and pins 6 and 7, which supply the CRT grid. The voltage induced into each secondary winding is approximately 3.3 kV. The CRT cathode and grid supplies each contain a half-wave rectifier (CR1030/CR1070) and an RC filter network. The CRT grid is prevented from becoming more negative than approximately 200 V with respect to the cathode by three neon lights connected in series between the grid and cathode.

High Voltage Regulator

The CRT cathode voltage is divided down through resistors R1080, R1081, R1082, R1083, R1084, and R1086 and applied to the summing junction of the regulator amplifier at the gate of FET Q1010. The other input to the summing junction is an adjustable voltage from R1001 through R1004. Transistors Q1010, Q1015, and Q1018 form the high voltage regulator. A change in voltage on the gate of Q1010 causes a change to appear on the drain which is coupled to the base of Q1015. A change in voltage on the base of Q1015 causes the current through Q1015/Q1018 to either increase or decrease. Since Q1015/Q1018 supply base drive to Q1020, the current through the oscillator will either increase or decrease and return the amplitude of the output signal from the oscillator to the correct value (an increase of current through Q1015 turns the oscillator on harder and increases the amplitude of the oscillations). The high voltage is adjusted by setting the current through R1004 into the summing junction with the adjustment of the High Voltage Adjust, R1001.

Diodes CR1005/CR1006/CR1010 are protection diodes to prevent reverse breakdown of the transistors Q1010/Q1015. R1008 and C1008 are an oscillation suppressor to prevent Q1010 from oscillating.

Intensity Control

The intensity control circuit consists of Q1040, Q1050, and Q1060A/B. The purpose of this circuit is to control the CRT beam current by controlling the CRT grid bias. The Intensity Control Circuit, although it is connected to the low voltage end of the cathode supply, does not vary the cathode voltage. The high voltage regulator circuit reacts to buck out any change that is applied to the cathode supply by the Intensity Control Circuit. Since the grid supply winding is very closely coupled to the cathode winding, its output voltage will change in the same proportion. The result is that a positive voltage applied by the Intensity Control Circuit causes the grid to be driven further negative. The Intensity Control Circuit has two inputs, the Intensity Control and a line voltage compensation function.

Assume the line voltage increases in value. The CRT filament voltage increases and the beam current will tend to increase. The emitter of Q1060A is connected through CR1056 to the +20 V unregulated supply. Since the line voltage increases, the +20 V will also increase. This causes the emitter of Q1060A to become more positive, which reduces the current through Q1060A/Q1050 and causes the base of Q1040 to go in the positive direction. The current through Q1040 will increase, causing its emitter to become more positive. This positive-going signal is coupled to the CRT cathode, causing the cathode voltage to go in the positive direction. This change in cathode voltage is coupled to the high voltage regulator and Q1015/Q1018 increases conduction. This causes the oscillator to increase conduction, increasing the amplitude of the oscillations. Since the amplitude of the oscillations has increased, the voltage induced into the secondary windings (CRT cathode and grid) goes more negative. Thus, the CRT cathode is returned to its normal operating level and the grid is made more negative with respect to the cathode, increasing the bias and preventing the beam current from increasing in response to an increase in line voltage. Also, the cathode is maintained at a constant level, thus maintaining a constant accelerating voltage. Due to the RC filtering in the intensity control circuit, the circuit will not react to short duration changes in line voltage. CR1040 limits the emitter voltage of Q1040 to −0.6 V.

The bias on the CRT can be changed manually by the adjustment of R1066, Intensity control. R1066 sets the base voltage on Q1060B, which also controls the current through Q1050. As the current through Q1050 is changed, the sequence of events described in the previous paragraph occurs and the bias on the CRT is changed (or the intensity is changed). The setting of R1066 determines the beam current during read time.

LOW VOLTAGE POWER SUPPLY

General

The Low Voltage Power Supply circuit provides the operating power for this instrument from seven regulated supplies and two unregulated supply. Electronic regulation is used to provide stable, low ripple output voltages. Each regulated supply is protected with a short protection circuit which decreases the output power of the supply if the supply is inadvertently shorted. The power input stage includes the Voltage Selector Assembly. This assembly allows selection of the operating voltage range and regulating range for the instrument.

Power Input

Power is applied to the primary winding of transformer T1101, through the 115 volt line fuse F1101, POWER switch S1101, Range Selector S1103, and the Voltage Selector S1104. The Range Selector connects the split primaries of T1101 in parallel for 115 volt range of operation, or in series for 230 volt range. A second line fuse, F1102, is connected into the circuit when the Range Selector switch is set to the 230 volt position to provide the correct protection for 230 V operation (F1102 current rating is one-half that of F1101). Thermal Switch S1102 is in series with the primary winding and disconnects the power if the temperature within the instrument becomes too great.

The Voltage Selector switch S1104 allows the instrument to regulate correctly on higher or lower than normal line voltages. Each half of the primary has taps above and below the 115 volt (230 V) point. As the Voltage Selector switch is switched from LO to M to HI, more turns are added to the primary winding. Therefore, whether the primary voltage has increased or decreased, the secondary voltage can be maintained at a nearly constant level ($E_S = E_P \times N_S/N_P$).

+15 Volt Supply

The +15 V supply provides the reference voltage for the rest of the supplies. The reference for the +15 volt supply is zener diode VR1175, which couples any error voltage in the +15 volt supply to an integrated circuit connected as an operational amplifier.

The +15 volt circuit consists of Q1185, a series regulator; U1170, an integrated circuit connected as an operational amplifier (the comparator and error amplifier); Q1180, the current amplifier; and CR1180/CR1181/CR1182, the short protection diodes. The voltage for this supply is obtained from the secondary winding of T1101, pins 19 and 21, and rectified by the full wave centered-tapped rectifier consisting of CR1170A/D. C1165B/C and R1187 provide the filtering for the supply.

The – input of U1170 is connected through R1175 and VR1175 to the +15 volt output. R1176 sets the proper operating current for VR1175. The + input of U1170 is connected through R1178 to the arm of a potentiometer, R1183. R1183, R1182, and R1184 form another divider to ground for the +15 volts. The +15 volts is connected through two dividers to the inputs of U1170, and any voltage change in the supply will be applied to both inputs. The change coupled to the + input is attenuated by the resistive divider and C1184; the voltage applied to the – input is applied undiminished by zener diode (VR1175); therefore, any change in the +15 volt supply will be felt primarily at the – input. The +15 V is adjusted by changing the position of the arm of R1183, +15 Adjust, which changes the voltage level at the + input of the operational amplifier.

Assume that the +15 volt supply goes more positive. Since the change is felt more at the – input of U1170, the output of the amplifier will go in the negative direction. This negative-going signal is coupled to the base of Q1180, which acts as an emitter follower and couples the change to the base of Q1185. A negative-going signal on the base of Q1185 causes it to decrease conduction, thereby decreasing the current through the load and returning the supply to the correct voltage.

Diodes CR1180, CR1181, and CR1182 in the base circuit of Q1180 are normally not conducting. The base-emitter junction voltage of Q1180/Q1185 and the IR drop across R1186/R1189 determines the voltage across the diodes. If the load on the +15 V supply is inadvertently increased by 0.7 A, the increased IR drop across R1189 will cause the diodes to turn on, shunting the drive to Q1180. Since the drive to Q1180 is shunted by the diodes, the load current cannot increase much more than approximately 0.7 A.

–15 Volt Supply

The negative 15 volt supply is referenced to the +15 volt supply and operates basically in the same manner. Q1225 is the series regulator, Q1210A/B form the comparator circuit, Q1220/Q1222 acts as an error amplifier, and CR1221/CR1222/CR1223 are the short protection diodes. The voltage for the supply is obtained from rectifiers CR1170B/C and filtered by C1228/R1228. Zener diode VR1215 and R1215 set the emitter current of Q1210A/B.

The base of Q1210B is connected to the junction of R1218 and R1219, which form a divider between +15 volts and –15 volts. Since R1218/R1219 are precision resistors and of the same value, their junction will be at 0 V, establishing the base voltage of Q1210B. The base of Q1210A is connected to ground through R1214. If the –15 volts tries to go in the positive direction, the base of Q1210B becomes more positive, causing the transistor to increase conduction. An increase of current through Q1210B causes its collector to go negative, increasing the current in Q1220. Q1222 amplifies the current from Q1220 and increases the drive to Q1225, causing the series regulator to increase conduction and return the –15 V supply to the correct voltage.

The short protection diodes, CR1221/CR1222/CR1223, operate in the same manner as previously described for the diodes in the +15 V supply.

–5 Volt Supply

The source voltage for the –5 V supply is obtained from the –15 volts, and the +15 volts is the reference voltage for the supply. The series regulator for this supply is Q1245; Q1240 is the error amplifier, and the comparator includes Q1230A/B. The base of Q1230B is connected to the junction of R1235/R1236, which is a divider between +15 V and –5 V. Q1230B is the sensing transistor of the comparator. Diodes CR1231, CR1232, and CR1233 are current limiting (short protection) diodes and are normally off.

If the –5 V supply tries to go in the negative direction, the base of Q1230B goes in the negative direction, increasing the current through the transistor. This causes Q1230A to decrease conduction and its collector becomes more negative. The negative-going signal is coupled through Q1240 to the base of Q1245, decreasing the current through the series regulator and returning the supply voltage to the correct value.

The total current for the –5 V load flows through the series regulator and through R1248 to the –15 volts. If the current through the load increases to the point where the base voltage of Q1240 is approximately –13.2 V, the collector current of Q1230A will be shunted through the diodes (CR1231, CR1232, CR1233) limiting the drive delivered to Q1225.

–50 Volt Supply

The voltage for the –50 V supply is obtained from pins 11 and 13 of the secondary of T1101. The full-wave rectifier consists of CR1150B/C. Transistors Q1250A/B form the comparator circuit with Q1250B referenced to +15 V through R1258/CR1258/CR1257. Q1260 is the error amplifier, Q1265 is the series regulator, and CR1263/CR1264 are short protection diodes. VR1262 is a level-shifting diode. Except for voltage levels and component values, the circuit configuration and operation of the –50 V supply is the same as the –15 V supply previously discussed.

The –50 V supply contains a shutdown circuit for the –50 volts in the event of a failure of the +200 V supply. The shutdown circuit includes R1257, CR1257 and CR1258. If a failure occurs in the +200 V supply, current

through R1257 is removed. With no current through R1257, CR1257/CR1258 become reverse biased, disconnecting the +15 V reference voltage from the base of Q1250B. The –50 V output will fall to zero and the high voltage supply for the CRT will be shut down to prevent damage to the CRT phospher.

+50 Volt Supply

The basic operation of the +50 volt supply is the same as the operation of the supplies previously discussed, so it will not be discussed in detail. The +50 V supply uses the same transformer winding as the –50 V supply and the full-wave rectifier consists of CR1150A/D. The series regulator is Q1165, the comparator is made up of Q1150A/B, with any change in the +50 volts being coupled to the base of Q1150B. The error amplifier is Q1152/Q1160, and CR1161/CR1162/CR1163 are the short protection diodes. CR1159 diverts some of the current from Q1150 away from Q1152, thus preventing excessive current through Q1152. CR1150 and CR1160 across the base-emitter junctions of Q1152 and Q1160 respectively, are protection diodes to prevent reverse base-emitter breakdown of the transistors. CR1152 prevents reverse base to collector current in Q1150A if the +50 V supply is shorted to ground. The RC combination of C1152 and R1152 perform high frequency roll-off to prevent amplifier instability.

+3.75 Volt Supply

Except for voltage levels and component values, the +3.75 volt supply is the same as the –5 volt supply, so a detailed circuit description will not be given for this supply. The +15 volts is the reference voltage for the supply.

The comparator consists of Q1190A/B with the reference voltage connected to the base of Q1190A. The error amplifier is Q1200/Q1202 and the series regulator is Q1205. The short protection circuit is composed of diodes, CR1201, CR1202 and CR1203 connected between the base of Q1202 through R1207, to the emitter of the series regulator, Q1205. The full-wave rectifier consists of CR1190A/B.

+200 Volt Supply

The +200 volt supply consists of a comparator, Q1110A/B, the error amplifier Q1112A/Q1140, the series regulator Q1145, a short protection transistor Q1112B, and the reference setting transistors Q1120A/B which are referenced to the +15 volts. The source voltage for this supply is obtained from the secondary winding (pins 17 and 18) of T1101 and rectified by a bridge rectifier consisting of diodes CR1110A-D.

The base of Q1120A is connected to +15 volts. The junction of R1124/R1125 in the emitter circuit is set at approximately –0.6 V by Q1120B. Therefore, the voltage drop across R1124 is virtually 15 volts which establishes the collector current through Q1120A at 1.5 mA. The current for Q1120A flows from +200 volts through R1120/R1122. Since the base of Q1110A is connected to the junction of R1120/R1122, the reference voltage for the comparator is set at 20 volts below the supply voltage by the IR drop in R1120. The base of Q1110B is connected through R1131 to the junction of R1132/R1134, which is a divider to ground for the +200 volts. When the output voltage is exactly +200 V, the drop across R1132 will be 20 volts. The bases of Q1110A/B will each be at 180 V above ground. Any change in the +200 volts will be transferred undiminished to Q1110A. The change will also be transferred to Q1110B, but will be diminished by the divider action of R1132/R1134. The signal on the collectors of Q1110A and Q1110B is amplified by Q1112A and coupled through Q1140 to the base of the series regulator, Q1145. The conduction of Q1145 will then change and return the +200 volt supply to the correct value. The collector supply voltage for Q1110/Q1112 is obtained from the unregulated +335 volts.

The +200 volt supply is protected from overload damage by a current limiting and lockout circuit. Current limiting occurs when the IR drop in R1149 reaches approximately 1 volt, turning CR1145 and Q1112B on. This shunts the drive current away from Q1140 and prevents Q1145 from delivering more than approximately 300 mA. If the load demands more than 300 mA, the output voltage will fall below +200 volts. When it falls to about +50 volts VR1143 will be turned on. Q1112B will then be turned on very heavily, eliminating all drive to Q1140/Q1145. Q1145 will be cut off completely and the output voltage will fall to zero. The supply cannot be restarted until power is shut off and C1142B/C1142A are discharged.

An overload indicator light is incorporated into the +200 volt supply which will flash off and on if there is a malfunction in either the +200 volt or +15 volt supplies. DS1133 is connected from +200 volts, through R1133 to +230 V unregulated. When the +200 volts is operating normally, the voltage across the neon is not enough to fire it. If the +200 volts decreases in value, the voltage across the neon will increase and fire the lamp. Capacitor C1133 is connected across DC1133 and causes it to act as a relaxation oscillator.

The diodes across the base-emitter junctions of the transistors are protection diodes to prevent reverse breakdown of the transistors. CR1112 shunts part of the current from the comparator away from Q1112A, so Q1112A only takes the current it needs.

A +335 volt unregulated supply is obtained by stacking the output voltage of T1101 secondary winding (pins 23 and 24) and the bridge rectifier, CR1105A-D on top of the +200 volt unregulated supply. The filter for the supply is R1108/C1108. The +335 V supply is fused by F1107, a 1/8 ampere fuse.

SECTION 4
SERVICING

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 4501.

Cover Removal

The top and bottom covers of the instrument are held in place by four slotted fasteners on each cover. To remove the covers, turn the fasteners approximately one-half turn and lift the cover off the instrument. The covers protect the instrument from getting dust in the interior of the instrument.

WARNING

Dangerous potentials exist at several points throughout this instrument. When this instrument is operated with the covers removed, do not touch exposed connections or components. Some transistors may have elevated cases. Disconnect power before cleaning the instrument or replacing parts.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis may prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the Type 4501 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

General. The Type 4501 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path which may result in instrument failure.

The top and bottom covers provide protection against dust in the interior of the instrument. Operation without covers in place neccessitates more frequent cleaning.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Exterior. Loose dust accumulated on the outside of the Type 4501 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

CRT. Clean faceplate protector and the CRT face with a soft, lint-free cloth dampened with denatured alcohol. The CRT mesh filter can be cleaned in the following manner:

1. Hold the filter in a vertical position and brush lightly with a soft #7 water-color brush to remove light coatings of dust or lint.

2. Greasy residues or dried-on dirt can be removed with a solution of warm water and a neutral-pH liquid detergent. Use the brush to lightly scrub the filter.

3. Rinse the filter thoroughly in clean water and allow to air dry.

4. If any lint or dirt remains, use clean low-pressure air to remove. Do not use tweezers or other hard cleaning tools on the filter as the special finish may be damaged.

5. When not in use, store the mesh filter in a lint-free, dust-proof container such as a plastic bag.

Interior. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-pressure air. Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning circuit boards.

The high-voltage circuits, particularly parts located in the high-voltage compartment and the area surrounding the post-deflection anode connector, should receive special attention. Excessive dirt in these areas may cause high-voltage arcing and result in improper instrument operation.

Lubrication

General. The reliability of potentiometers and other moving parts can be maintained if they are kept properly lubricated. Use a cleaning-type lubricant (e.g., Tektronix Part No. 006-0218-00) on switch contacts. Lubricate switch detents with a heavier grease (e.g., Tektronix Part No. 006-0219-00). Potentiometers which are not permanently sealed should be lubricated with a lubricant which does not affect electrical characteristics (e.g., Tektronix Part No. 006-0220-00). The pot lubricant can also be used on shaft bushings. Do not over lubricate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix, Inc. Order Tektronix Part No. 003-0342-00. The fan-motor bearings are sealed and do not require lubrication.

Visual Inspection

The Type 4501 should be inspected occasionally for such defects as broken connections, improperly seated transistors, damaged circuit boards and heat-damaged parts.

The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of over-heating be corrected to prevent recurrence of the damage.

Transistor Checks

Periodic checks of the transistors in the Type 4501 are not recommended. The best check of transistor performance is actual operation in the instrument. More details on checking transistor operation are given under troubleshooting.

Recalibration

To assure accurate measurements, check the calibration of this instrument after each 500 hours of operation or every six months if used infrequently. Any time the target operating level is adjusted (see General Operating Information in the OPERATING SECTION), the Read Amplifier should be calibrated. These steps can be performed without performing a complete calibration of the instrument. In addition, replacement of components may necessitate recalibration of the affected circuits. Complete calibration instructions are given in the Calibration section.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 4501. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles. See the Circuit Description section for complete information.

Troubleshooting Aids

Diagrams. Complete circuit diagrams are given in foldout pages in the Diagrams section. The component number and electrical value of each component in this instrument are shown on the diagrams. Each main circuit is assigned a series of component numbers. Table 4-1 lists the main circuits in the Type 4501 and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams. The portions of the circuit mounted on circuit boards (or cards) are enclosed with a blue line.

TABLE 4-1

Component Numbers

Component numbers on diagrams	Diagram number	Circuit
0- 200	1	Read Raster
200- 400	2	Z Axis
400- 600	3	X-Y Amplifier
600- 700	4	Storage
700-1000	5	Read Amplifier
1000-1100	6	CRT
1100-1300	7	Low Voltage

Circuit Boards (and cards). The location of circuit boards and cards, within the instrument, is shown in a photograph on the back of the first sheet of the Diagrams Section (Section 8). In Section 8 the location of pins and components, for each of the circuit boards and cards, is pointed out on a photograph. Each card or board is assigned an assembly number. This assembly number (A-1, A-2, etc.) appears under the picture, on the appropriate schematic, and in the parts list.

Wiring Color-Code. All insulated wire and cable used in the Type 4501 is color-coded to facilitate circuit tracing. Signal carrying leads are identified with one or two colored stripes. Table 4-2 gives the wiring color-code for the power-supply voltages used in the Type 4501. A red background color indicates a positive voltage and a violet background indicates a negative voltage.

TABLE 4-2

Power Supply Wiring Color Code

Supply	Background color	First stripe	Second stripe
+15 V	Red	Brown	
+200 V	Red	Yellow	
+50 V	Red	Orange	
+3.75 V	Red	Black	
−5 V	Violet	Black	
−15 V	Violet	Brown	
−50 V	Violet	Red	
+335			
UNREG	Red	Yellow	Blue

Capacitor Marking. The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type 4501 are color-coded in picofarads using a modified EIA code .

Diode Color-Code. The cathode end of each glass encased diode is indicated by a stripe, a series of stripes or a dot. For most silicone or germanium diodes with a series of stripes, the color-code identifies the three significant digits of the Tektronix Part Number using the resistor color-code system (e.g., a diode color-coded pink (or blue)—brown—gray—green indicates Tektronix Part Number 152-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

Transistor and Integrated Circuit (IC) Lead Configuration. Fig. 4-1 shows the lead configurations of the transistors and ICs used in this instrument. This view is as seen from the bottom of the transistor or IC.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 4501.

1. Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer or equivalent.

Purpose: To test the semiconductors used in this instrument.

2. Multimeter

Description: VOM, Minimum sensitivity, 20,000 ohms/volt. Accuracy, within 3% 0 V to 350 V; within 1% at 3300 V with high-voltage probe.

NOTE

Circuit loading at high impedance should be taken into consideration.

Purpose: To check voltages and for general troubleshooting in this instrument.

3. Test Oscilloscope

Description: DC to 75 MHz frequency response, 50 millivolts to 50 volts/division deflection factor. A 10X probe should be used to reduce circuit loading.

Purpose: To check waveforms in this instrument.

4. Circuit Board Extenders

Description: 30 Pin Extender, Tektronix Part No. 670-0818-00. 56 Pin Extender, Tektronix Part No. 670-0819-00. A 56 Pin Inverting Extension is available which permits the circuit board to be inverted, rather than turning the instrument over. When extended, if the circuit board components are underneath, the circuit board can be inverted by using this extender. Tektronix Part No. 670-0820-00.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining

steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section.

2. Check Associated Equipment. Before proceeding with troubleshooting of the Type 4501, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

3. Visual Check. Visually check the portion of the instrument in which the trouble may be located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

4. Check Instrument Calibration. Check the calibration of this instrument, or the affected circuit if the trouble appears in one circuit. The apparent trouble may only be a result of misadjustment or may be corrected by calibration. Complete calibration instructions are given in the Calibra tion section.

5. Isolate Trouble to a Circuit. To isolate trouble to a circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. When trouble symptoms appear in more than one circuit, check affected circuits by taking voltage and waveform readings.

Incorrect operation of all circuits often indicates trouble in the power supply. Check first for correct voltage of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits. Table 4-3 lists the tolerances of the power supplies in this instrument. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. Use the procedures given in the Calibration section to adjust the power supplies.

6. Check Circuit Board Interconnections. After the trouble has been isolated to a particular circuit, check the connectors on the circuit board for correct connection.

7. Check Voltages and Waveforms. Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

TABLE 4-3

Power Supply Tolerance and Ripple

Power supply	Tolerance	Maximum Ripple (peak to peak)
+15	±0.1 V	5 mV or Less
+200	±4 V	5 mV or Less
+50	±1 V	5 mV or Less
+3.75	±0.1 V	5 mV or Less
−5	±0.2 V	10 mV or Less
−15	±0.2 V	5 mV or Less
−50	±1 V	5 mV or Less
−3300	±33 V	

NOTE

Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first diagram page.

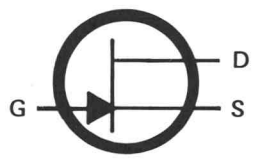
8. Check Individual Components. The following procedures describe methods of checking individual components in the Type 4501. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

A. TRANSISTORS AND INTEGRATED CIRCUITS. The best check of transistor or IC operation is actual performance under operating conditions. If a transistor or IC is suspected of being defective, it can best be checked by substituting a new component or one which has been checked previously. However, be sure that circuit conditions are not such that a replacement transistor or IC might also be damaged. If substitute transistors are not available, use a dynamic tester (such as Tektronix Type 576 or 575). Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

CAUTION

POWER switch must be turned off before removing or replacing transistors or ICs.

Circuit symbol for the Junction FET is shown below.



Junction FET

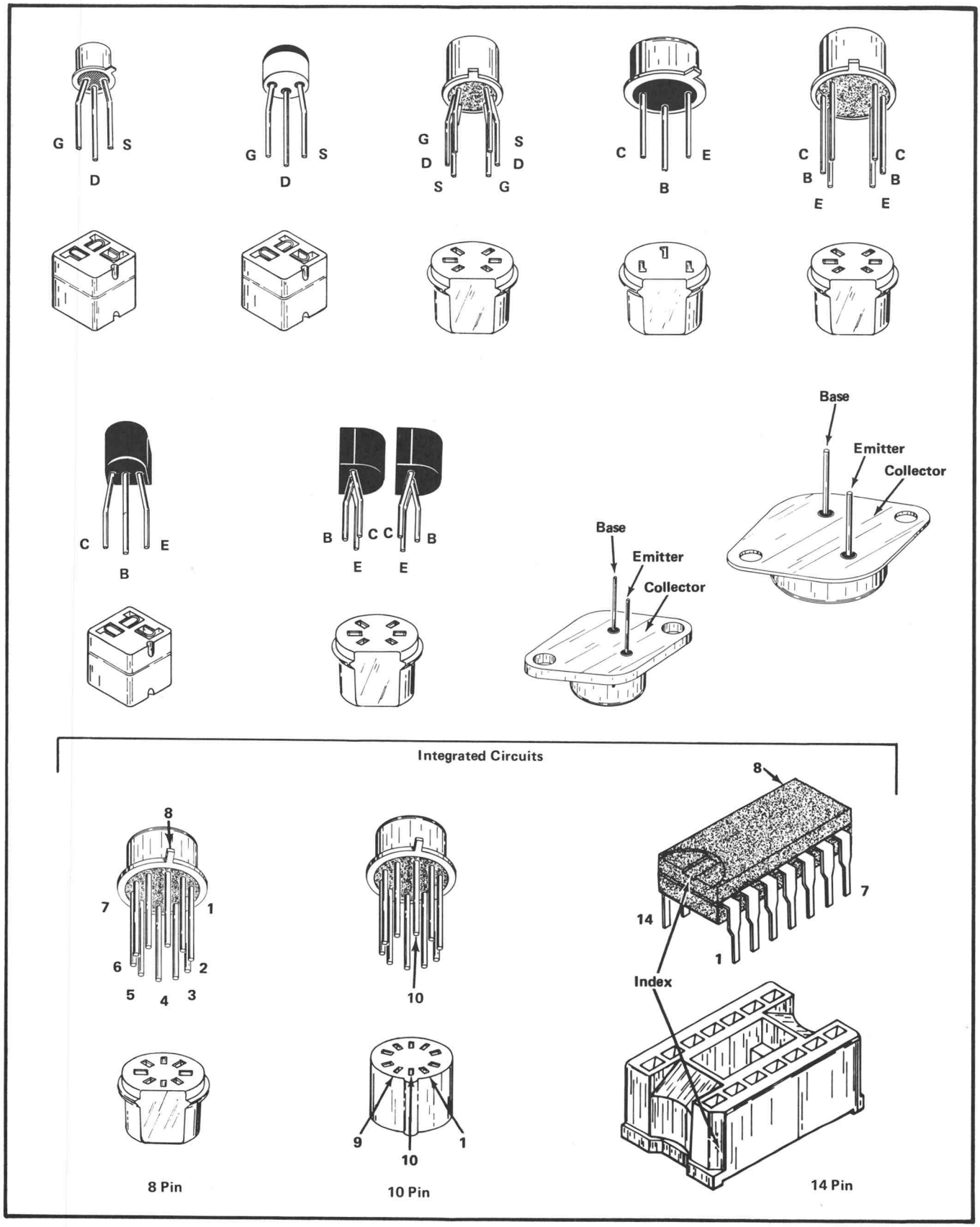


Fig. 4-1. Lead configuration of transistors and integrated circuits used in this instrument.

B. REED-DRIVE COILS. The reed-drive coils can be checked for correct operation as follows (the coils have four mounting leads for rigidity; make measurements between the two leads on either end of the coil): 1) Check the DC resistance of the coil with an ohmmeter; take the associated circuitry into account on resistance measurements; typical resistance values are given in the Electrical Parts List). 2) Check the DC voltage drop across the coil when the actuating level is applied. 3) If both the resistance and voltage are correct, the coil can be assumed to be correct; check the reed relay position and continuity. 4) If the resistance is incorrect (take into account surrounding circuitry), disconnect the coil and check the resistance again. 5) If the voltage across the coil is incorrect but the coil resistance is correct, check the circuit originating the actuating level.

9. Repair and Readjust the Circuit. If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 4501 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts lists for value, tolerance, rating and description.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance in the instrument, particularly at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Special Parts. In addition to the standard electronic components, some special components are used in the Type 4501. These components are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special components are indicated in the Electrical Parts List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument Type.

2. Instrument serial number.

3. A description of the part (if electrical, include circuit number).

4. Tektronix Part Number.

Component Replacement

WARNING

Disconnect the instrument from the power source before replacing components.

Circuit Board Replacement. If a circuit board is damaged beyond repair, either the entire assembly including all soldered on components, or the board only, can be replaced.

Part numbers are given in the Mechanical Parts List for either the completely wired or the unwired board. Most of the boards are plug-in type boards and can be removed by grasping the handle, located in the center of the board, and firmly pulling straight out. Disconnect the coaxial leads from the board by pulling straight up on the sub-miniature coaxial connector. The coaxial leads connected to the boards are long enough to allow the boards to be operated on an extender for troubleshooting. To replace the boards, reverse the order of removal. Insert the board in the edge guide and firmly press straight in; ensure that the grooved ring on the handle is seated in the holder mounted on the chassis.

To remove boards that are not plug-in type boards, use the following procedure:

1. Disconnect all pin connectors from the board and unsolder any soldered connections.

2. Remove all screws holding the board to the chassis.

3. Lift the circuit board out of the instrument. Do not force or bend the board.

4. To replace the board, reverse the order of removal. Replace the pin connectors carefully so they mate correctly with the pins. If forced into place incorrectly positioned, the pin connectors may be damaged.

Transistor and Integrated Circuit Replacement. Transistors and Integrated Circuits should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors or ICs may affect the calibration of this instrument. When transistors or ICs are replaced, check the operation of that part of the instrument which may be affected.

Replacement transistors or ICs should be of the original type or a direct replacement. Fig. 4-1 shows the lead configuration of the transistors and ICs used in this instrument. Some plastic case transistors have lead configurations which do not agree with those shown here. If a transistor is replaced by a transistor which is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. Transistors which have heat radiators or are mounted on the chassis use silicone grease to increase heat transfer. Replace the silicone grease when replacing these transistors.

WARNING

Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.

CAUTION

POWER switch must be turned off before removing or replacing transistors or ICs.

Glass Reed-Relay Replacement. The glass reed-relays used in this instrument are pressurized. Therefore, safety glasses should be worn to protect the eyes when replacing these relays. To avoid damage to the reed-relays, do not apply stress to the metal-glass bond. When it is necessary to bend a lead, use two pairs of long-nose pliers. Before replacing a reed-relay, be sure the actuating circuit is not at fault. It is important that the replacement reed-relay be correctly positioned within the drive-coil assembly with the same lead length as the original to provide similar magnetic characteristics.

REMOVAL:

1. Observe the physical position of the leads and glass bulb of the old reed-relay.

2. Cut the leads of the old reed-relay at the bend in the lead. This leaves a solder post for installation of the new reed-relay.

3. Pull the old reed-relay out of the drive coil.

REPLACEMENT:

1. Slip the new reed-relay into the drive coil. If the reed-relay has three leads, slip the single lead in first.

2. Position the new reed-relay in exactly the same physical position as the old one.

3. Position the leads correctly and solder the new reed-relay to the solder posts (old reed-relay leads). Avoid excessive heat on the reed-relay; use a heat-sink on the leads if soldering close to the glass body.

4. Clip off the excess lead length beyond the solder posts. Do not clip the leads closer than 1/4 inch from the glass body.

Cathode-Ray Tube Replacement

WARNING

High vacuum cathode ray tubes are dangerous to handle. To prevent personal injury from flying glass in case of tube breakage, wear a face mask or safety goggles, and gloves.

Handle the CRT with extreme care. Do not strike or scratch it. Never subject it to more than moderate force or pressure when removing or installing.

Always store spare CRT's in original protective cartons. Save cartons to dispose of used CRT's.

The following procedure outlines the removal and replacement of the cathode-ray tube:

1. Remove the top and bottom covers as described previously. Set the Type 4501 on its right side.

2. Disconnect the lead to the CRT target (Fig. 4-2).

3. Disconnect the CRT socket.

4. Disconnect the deflection plate connectors and target clip. Be careful not to bend the deflection plate pins. Fig. 4-3 shows the wiring color code for the deflection plate connectors.

5. Remove the CRT faceplate protector.

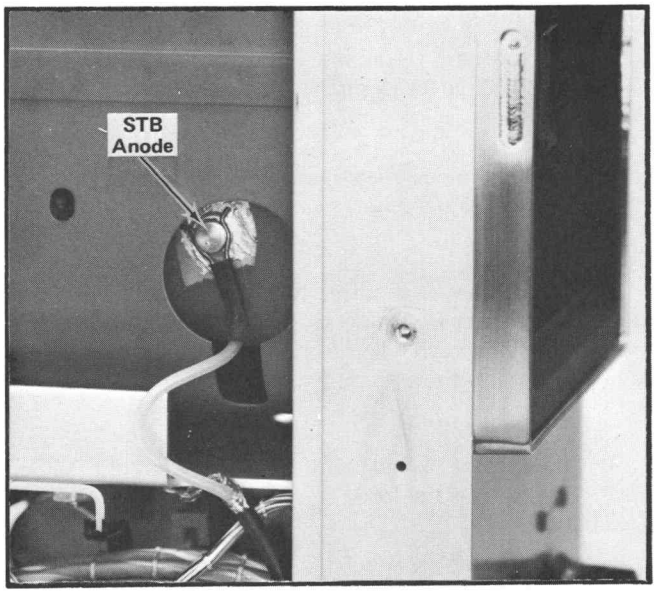


Fig. 4-2. Location of CRT target electrode.

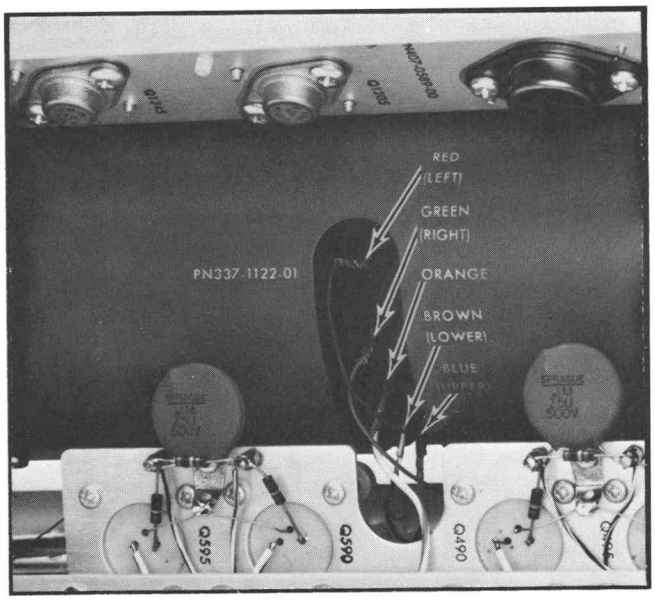


Fig. 4-3. Wiring color code for CRT deflection plate pins.

6. Loosen the clamp around the neck of the CRT by loosening the phillips head screw (see Fig. 4-4). Do not completely remove the screw.

7. Hold one hand on the CRT faceplate and with the other hand, gently push forward on the CRT base. As the CRT starts out of the shield, grasp it firmly and continue to pull it forward out of the instrument. Be careful not to bend the deflection plate pins. It may be necessary to

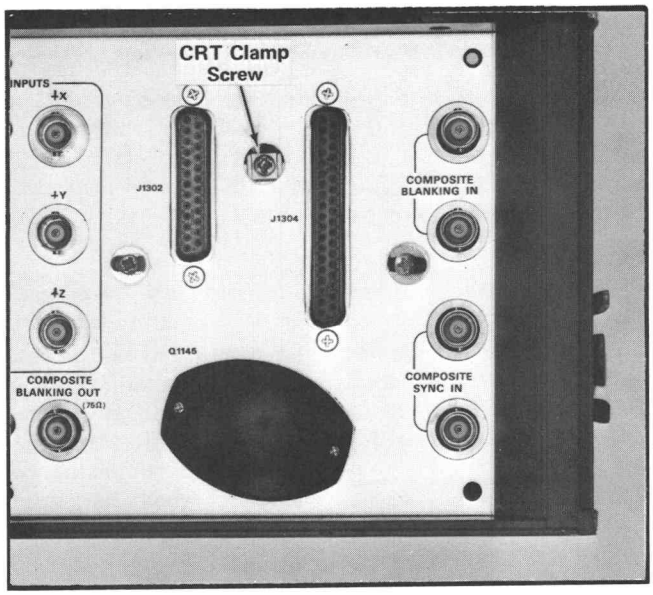


Fig. 4-4. Location of CRT clamp and positioning screws.

slightly press the CRT toward the top of the instrument to allow the target electrode connector to clear the CRT shield.

Replacing the Cathode-Ray Tube. Slide the CRT into the shield. Guide the CRT base into the base clamp and slide the CRT toward the rear of the instrument far enough to allow room for the faceplate protector.

NOTE

If a new CRT received from the factory is marked "Flood Gun Heaters Reversed", then the flood gun heaters must be connected in reverse to the way shown on the Storage System diagram 4.

Place the faceplate protector in place and secure with four phillips head screws.

Pushing on the CRT base, slide the CRT forward until the CRT face touches the faceplate protector.

Tighten the CRT base clamp screw (see Fig. 4-4).

Loosen the two side screws on the clamp assembly (Fig. 4-4). Align the CRT faceplate squarely with the front of the instrument. Tighten the two side screws.

Replace the CRT base socket. Replace the deflection plate pin connectors and target electrode connector. Be careful not to bend the neck pins.

NOTE

After electrical connections have been made, ensure that the collimation bands are making contact by checking the performance of the instrument. It may be necessary to re-align the CRT with the graticule. Loosen the two side screws on the base clamp (Fig. 4-4). Rotate the CRT the necessary amount and re-tighten the screws.

Fuse Replacement. Table 4-4 gives the rating, location and function of the fuses used in this instrument.

TABLE 4-4

Fuse Ratings

Circuit Number	Rating	Location	Function
F1101	2 A Slow Blow	Voltage Selector Assembly	115 V Line
F1102	1 A Slow Blow	Voltage Selector Assembly	230 V Line
F1107	1/8 A Fast Blow	Low Voltage Regulator Circuit Board	+335 V UNREG

High-Voltage Compartment. The components located in the high-voltage compartment can be reached for maintenance or replacement by using the following procedure:

1. Remove the top cover of the instrument as described in this section.

2. Remove the high-voltage shield.

3. Remove the three screws which hold the cover on the high-voltage compartment and remove the cover.

4. Remove the two plastic screws holding the circuit board in place.

5. To remove the complete wiring assembly from the high-voltage compartment, unsolder the two diodes from the high-voltage transformer (see Fig. 4-5). The other leads are long enough to allow the assembly to be lifted out of the compartment to reach the parts on the under side.

6. To replace the high-voltage compartment, reverse the order of removal.

NOTE

All solder joints in the high-voltage compartment should have smooth surfaces. Any protrusions may cause high-voltage arcing at high altitudes.

Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Since the low-voltage supply affects all circuits, calibration of the entire instrument should be checked if work has been done in the low-voltage supply or if the power transformer provides a quick and convenient means of checking instrument operation.

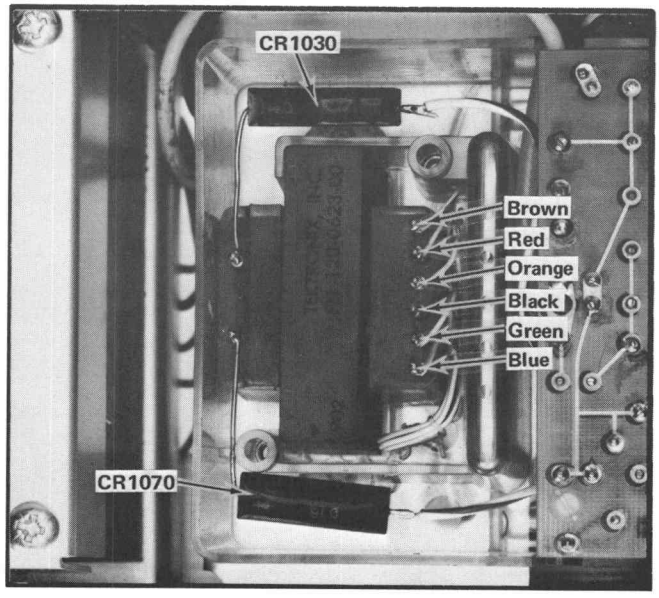


Fig. 4-5. Wiring color code for high voltage transformer.

NOTES

SECTION 5
CALIBRATION

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

To assure instrument accuracy, check the calibration of the Type 4501 every 500 hours of operation, or every six months if used infrequently. Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

This section provides several features to aid in checking or calibrating the instrument. For example:

Index. The short-form procedure lists the step numbers and titles of the complete calibration procedure and gives the page on which each step begins. Therefore, the short-form procedure can be used to locate a step in the complete procedure.

Calibration Record. The short-form procedure can be reproduced and used as a permanent record of instrument calibration. Spaces are provided to check off each step as it is completed and to record performance data.

Abridged Calibration Procedure. The short-form procedure lists the adjustments necessary for each step and the applicable tolerance for correct calibration. The experienced technician who is familiar with the calibration of this instrument can use this procedure to facilitate checking or calibrating.

Complete Calibration. Completion of each step in the complete calibration procedure checks this instrument to the performance requirements given in Section 1, and gives the procedure to return each adjustment to its optimum setting. Limits, tolerances and waveforms in this procedure are given as calibration guides and are not instrument specifications. Where possible, instrument performance is checked before an adjustment is made. For best overall instrument performance, make each adjustment to the exact setting even if the CHECK is within the allowable tolerance.

Partial Calibration. To check or adjust only part of this instrument, start with the nearest equipment required picture preceding the desired portion. To prevent recalibration of other parts of the instrument when performing a partial calibration readjust only if the tolerance given in the CHECK part of the step is not met. If an adjustment is made, any steps listed in the INTERACTION part of the step should also be checked for correct tolerance.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories or its equivalent is required for complete calibration of the Type 4501. Specifications given are the minimum necessary for accurate calibration. Therefore, some of the recommended equipment may have specifications which exceed those given. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the quickest and most accurate calibration, special Tektronix calibration fixtures are used where necessary. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Test Oscilloscope with 10X Probe and 1X Probe. Vertical amplifier: dual trace; bandwidth, DC to 100 MHz; deflection factor, .05 V/division through 10 V/division. Horizontal amplifier: normal and delayed sweeps; 10X Mag; single sweep; horizontal sweep and gate outputs. Tektronix Type 454 recommended.

2. Square-Wave Generator. Frequency, 1 kHz through 1 MHz; output amplitude, 400 mV. Tektronix Type 106 Square-Wave Generator recommended.

3. Sine-Wave Generator. 10 kHz through 10 MHz. Output amplitude, 0.5 volts through 5 volts.

4. Amplitude Calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 0.5 volts through 5 volts; output frequency, 1 kHz square wave. Tektronix Calibration Fixture 067-0502-01 recommended.

5. Variable Autotransformer. Must be capable of supplying at least 125 watts over a voltage range of 90 to 136 volts (180 to 272 volts for 230-volt nominal line). If autotransformer does not have an AC (RMS) voltmeter to indicate output voltage, monitor output with an AC (RMS) voltmeter.

6. DC Voltmeter. Minimum sensitivity, 20,000 ohms/volt. Calibrated to within 1% at +15 volts and −3300 volts. For example, Triplett Model 630 NA.

7. Termination. Feedthrough; impedance, 75 ohms. Tektronix Part No. 011-0103-02.

8. Termination. End-line; impedance, 75 ohms. Tektronix Part No. 011-0102-00.

9. Termination. Impedance 50 ohms; end-line. Connectors, GR to BNC. Tektronix Part No. 017-0083-00.

10. Cable. Impedance, 50 ohms; electrical length, 5 ns; connectors, GR 874. Tektronix Part No. 017-0502-00.

11. Cable, coaxial. Impedance, 50 ohms. Length, 42 inches; connectors, BNC. Three each. Tektronix Part No. 012-0057-00.

12. Dual-Input BNC Connector. Provides matched signal path to both inputs, either X, Y, or Z axis. Tektronix Part No. 067-0525-00.

13. BNC, T Connector. Tektronix Part No. 103-0030-00.

14. 8 kΩ Resistors, 1/4 watt, 2 each. 2 kΩ potentiometers, 2 each. Used to construct a sweep attenuator and a gate attenuator. Provides a 1 volt sweep and blanking pulse to the Type 4501. Construct according to the diagram shown below.

SHORT-FORM PROCEDURE

Type 4501, Serial No. _____

Calibration Date _____

Calibrated by _____

POWER SUPPLIES

1. Check/Adjust +15-Volt Power Supply — Page 5-5

   +15 volts, ±0.1 volt.

2. Check Low-Voltage Power Supplies — Page 5-5

3. Check Low-Voltage Power Supply Regulation and Ripple — Page 5-6

   Regulation and ripple, optional check.

4. Adjust High Voltage — Page 5-7

   −3300 volts, ±33 volts.

5. Check High Voltage Regulation — Page 5-7

   (Optional check).

6. Check Composite Sync/Composite Blanking Outputs — Page 5-7

7. Adjust Focus, Astigmatism and Trace Rotation — Page 5-9

STORAGE SYSTEM

8. Check Operating Level Range — Page 5-10

   Between +100 volts and +285 volts.

9. Adjust Operating Level — Page 5-10

   Optimum Stored display.

10. Adjust Collimation and Flood Gun Grids — Page 5-12

    Maximum uniform brightness over the storage target area.

11. Adjust Non-Store Level — Page 5-12

    Adjusted for no storage.

Z-AXIS AMPLIFIER

12. Adjust Z-DC Bal and DC Level Page 5-13

    Minimum shift of DC level while rotating R293.

13. Check/Adjust Amplifier Gain Page 5-14

    20 volts peak-to-peak output at pin S.

14. Check/Adjust Low Frequency CMRR Page 5-14

    Less than 0.4 volts as displayed on the test oscilloscope.

15. Check/Adjust Transient Response Page 5-14

    Aberrations within 5% of displayed waveform amplitude.

16. Check Z Axis Bandwidth Page 5-15

    Equal to or greater than 14.4 volts peak-to-peak.

17. Check/Adjust Common Mode Rejection Ratios Page 5-15

    CMRR 500 to 1.

18. Check Limiting Page 5-15

    0.5 volts beam off. 1 volt beam on.

X AND Y AMPLIFIERS

19. Check/Adjust X-Y Gain and Positioning Page 5-16

    Raster amplitude Y-axis 7.5 cm. X-axis 10 cm.

20. Check/Adjust Y Position Center Page 5-16

    Trace centered vertically on the CRT.

21. Adjust Y DC Bal Page 5-16

    Minimum shift of trace while varying R538.

22. Check/Adjust Y Write Sens Page 5-17

    Display 5 cm vertically.

23. Adjust Y Diff Bal Page 5-17

    Minimum deflection.

24. Adjust Transient Response Page 5-18

    Less than 2 mm of aberrations.

25. Check Bandwidth Page 5-18

    Less than 3 dB down.

26. Check/Adjust High Frequency CMRR Page 5-18

    10 MHz CMRR 10:1; 1 MHz CMRR 100 to 1.

27. Check Low Frequency Common Mode Rejection Page 5-18

    CMRR 500 to 1.

28. Check/Adjust X Position Center Page 5-19

    Trace centered horizontally on the CRT.

29. Adjust X DC Bal Page 5-19

    Minimum shift of trace while varying R438.

30. Check/Adjust X Write Sens Page 5-19

    Display 5 cm horizontally.

31. Adjust X Diff Bal Page 5-20

    Minimum deflection.

32. Adjust Transient Response Page 5-20

    Less than 2 mm of aberrations.

33. Check Bandwidth Page 5-20

    Less than 3 dB down.

34. Check/Adjust High Frequency CMRR Page 5-20

    CMRR 10 to 1 or greater.

READ AMPLIFIER

MODULATOR

COMPLETE CALIBRATION PROCEDURE

General

The following procedure allows the Type 4501 to be calibrated with the least interaction of adjustments and reconnection of equipment. An equipment required picture is shown for each group of checks and adjustments to identify the test equipment used. Following the picture in each case is a list of front panel control settings for the Type 4501 that are changed for the new group of checks and adjustments. Each step following the test equipment picture continues from the equipment setup and control settings used in the preceding step(s) unless noted otherwise. External controls or adjustments of the Type 4501 referred to in this procedure are capitalized (e.g., INTENSITY). Internal adjustment names are initial capitalized only (e.g., High Voltage).

All waveforms shown in this procedure were taken with a Tektronix Oscilloscope Camera System. The following procedure uses the equipment listed under Test Equipment Required. If equipment is substituted, control settings or equipment setup may need to be altered to meet the requirements of the instrument used. Detailed operating instructions for the test equipment are not given in this procedure. If in doubt as to the correct operation of any of the test equipment, refer to the instruction manual for that unit.

NOTE

This instrument must be calibrated at an ambient temperature between +20°C and +30°C. The performance of this instrument can be checked at any temperature within the 0°C to +50°C range. If the ambient temperature is outside the given range, see Section 1 for the applicable tolerances.

Preliminary Procedure for Complete Calibration

1. Remove the top and bottom covers from the Type 4501.

2. Set the line selector to 115 volts (230 V) and the range selector to medium.

3. Connect the Autotransformer to a suitable power source.

4. Connect the Type 4501 to the Autotransformer Output.

5. Set the Autotransformer Output voltage to 115 volts (230 V).

6. Set the POWER switch to ON. Allow at least 30 minutes warm-up before proceeding.

7. Throughout this procedure, connect the shorting cap to the unused X, Y, and Z inputs.

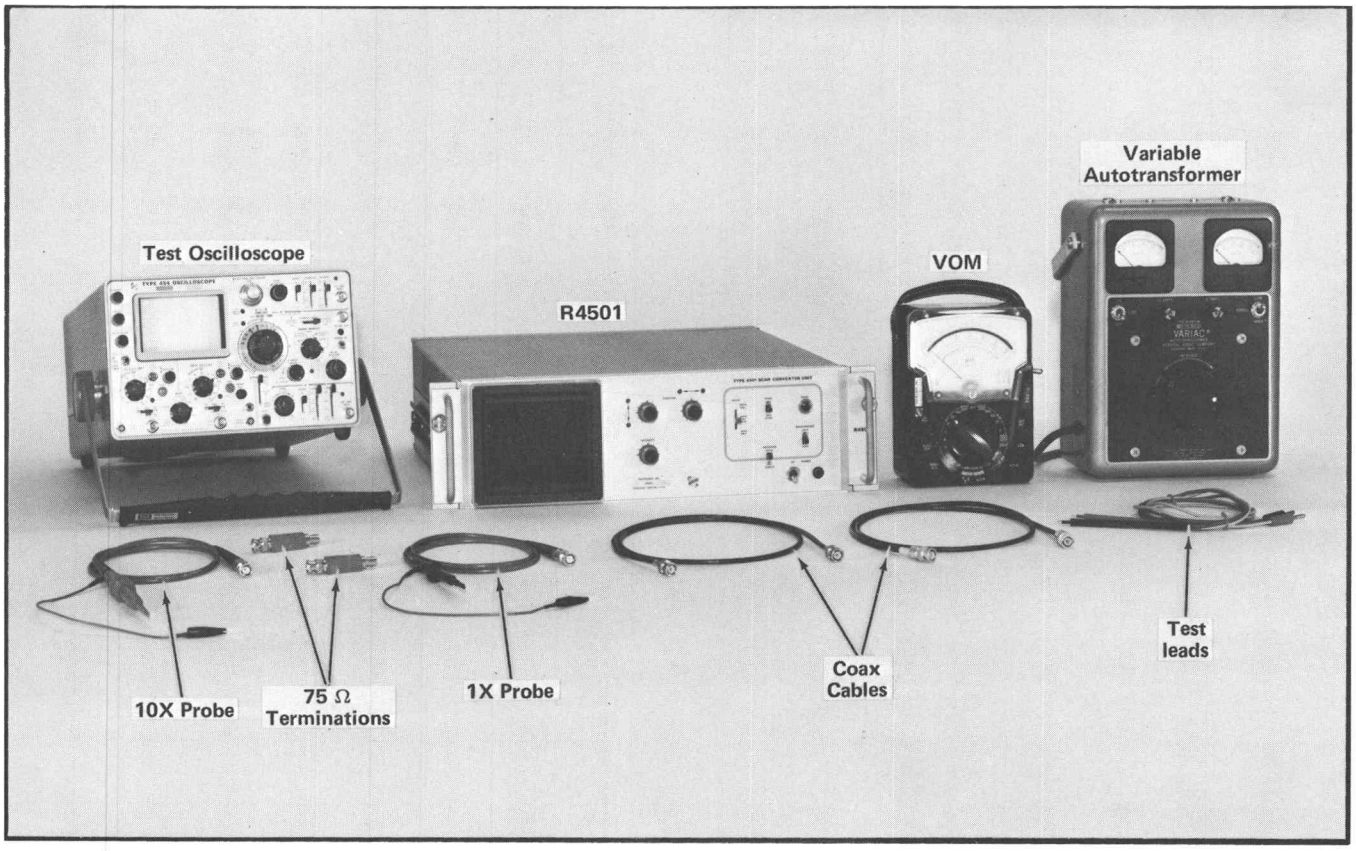


Fig. 5-1. Test equipment required for Step 1 through 6.

POWER SUPPLIES

Control Settings

Type 4501

POSITION	Centered
INTENSITY	Centered
MODE	WRITE AND READ
STORE/NON-STORE	NON-STORE
PROGRAM	LOCAL
BACKGROUND	DARK
Int/Ext Video	Int

Test Oscilloscope (Optional-to check Ripple)

Intensity	Nominal Brightness
Time Base	
Horizontal Display	A
Time/Div	2 ms
A Sweep Mode	Norm Trig
A Triggering	
Slope	+
Coupling	AC
Source	Line
Vertical Amplifier	
Mode	CH 1
Input CH 1	AC
Volts/Div	5 mV

1. Check/Adjust +15 Volt Supply

a. Test equipment required for steps 1 through 5 is as shown in Fig. 5-1.

b. Connect the DC voltmeter between the +15 volt test point and ground (see Fig. 5-2).

c. CHECK—The +15 volts should be within ±.1 volt.

d. ADJUST—Adjust the +15 volt adjust, R1183 (see Fig. 5-3) for exactly +15 volts.

e. INTERACTION—Operation of all circuits within the Type 4501 is affected by the +15 volt supply.

2. Check Low Voltage Power Supplies

a. Connect the DC voltmeter between each low voltage test point and chassis ground. See Fig. 5-2 for test point locations.

b. CHECK—Each supply is within the tolerance listed in Table 5-1.

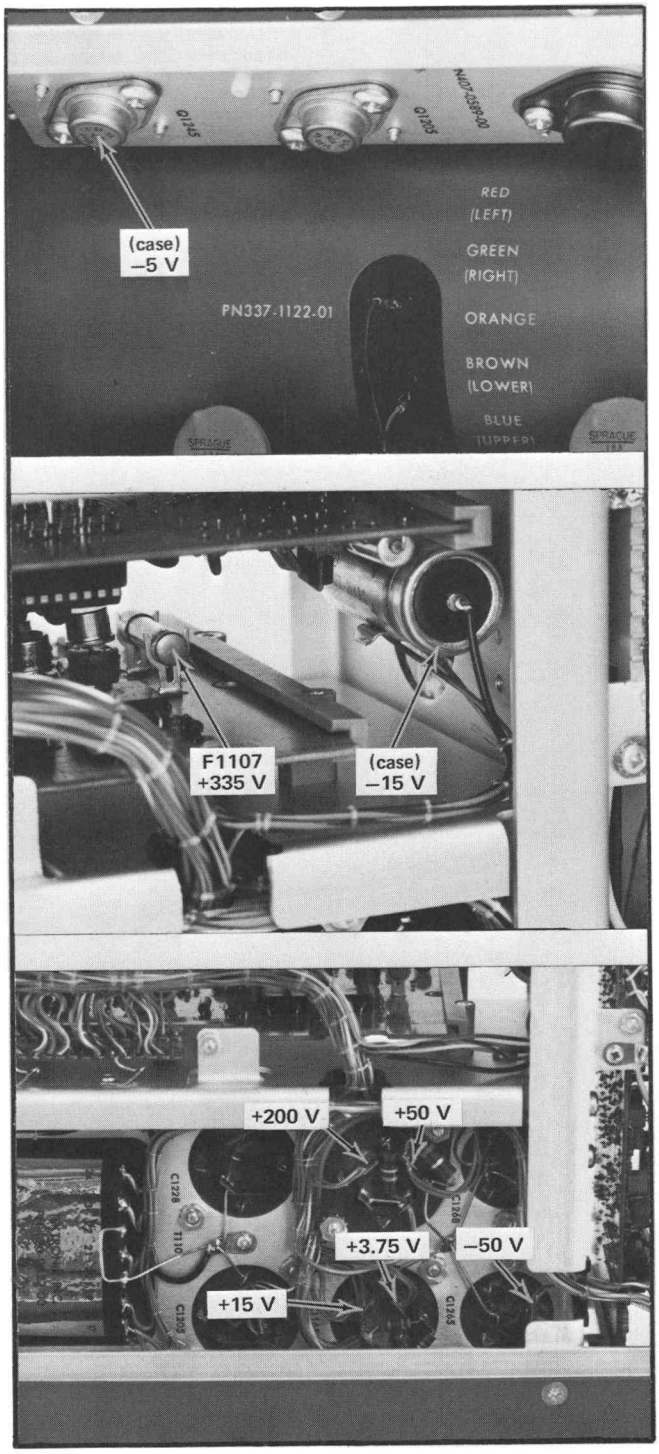


Fig. 5-2. Location of Low Voltage test points.

3. (Optional) Check Low Voltage Power Supply Regulation and Ripple

a. To check regulation connect the DC voltmeter between each low voltage supply test point and chassis ground. To check ripple, connect the 1 X probe from the test oscilloscope channel 1 input connector to each test point.

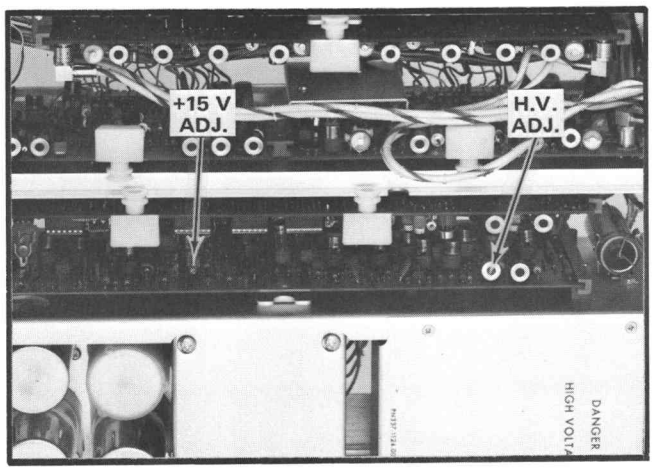


Fig. 5-3. Location of +15 V and High Voltage adjustments.

TABLE 5-1

Supply	Tolerance	Maximum Line Frequency Ripple
+15 V	Within 0.1 V	10 mV
+200 V	Within 4 V	20 mV
+50 V	Within 1 V	10 mV
+3.75 V	Within 0.1 V	10 mV
–5 V	Within 0.2 V	20 mV
–15 V	Within 0.2 V	10 mV
–50 V	Within 1 V	10 mV
+335 V Unreg		

b. Set the Autotransformer Output to 104 VAC.

c. CHECK—Each supply output and ripple amplitude must be within the tolerance listed in Table 5-1.

NOTE

Power supply voltages and ripple tolerances in this step are guides to correct instrument operation, not instrument performance requirements. Actual values may exceed listed tolerances with no loss in measurement accuracy, if the instrument meets the performance requirements in Section 1 as tested in this procedure.

d. Set the autotransformer output to 126 VAC.

e. CHECK—Each supply output and ripple amplitude must be within the tolerance listed in Table 5-1.

f. Return the autotransformer output to 115 VAC and disconnect the DC Voltmeter and Test Oscilloscope.

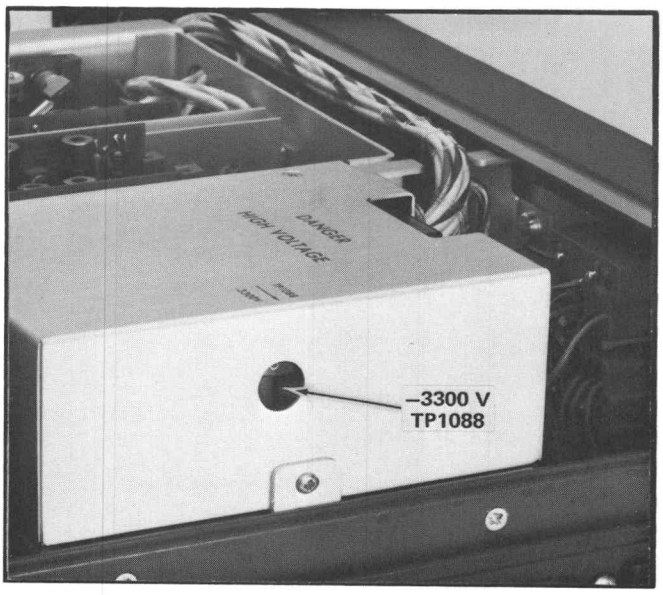


Fig. 5-4. High Voltage test point.

4. Adjust High Voltage

a. Connect the DC Voltage between ground and the negative 3300 volt test point (see Fig. 5-4).

b. CHECK—Meter reading must be negative 3300 volts, ±33 volts.

c. ADJUST—R1001, High Voltage (Fig. 5-3) for a meter reading of exactly −3300 volts.

5. (Optional) Check High Voltage Regulation

a. With the DC Voltmeter connected between ground and the -3300 volt test point, and the high voltage within the limits stated in step 4b, adjust the autotransformer for an output of 104 VAC and then 126 VAC to check the regulation of the high voltage supply.

b. CHECK—Meter reading should not vary more than ±33 volts when checking regulation.

c. Remove the DC voltmeter and return the autotransformer output to 115 VAC.

6. Check Composite Sync/Composite Blanking Outputs

a. Connect the 75 ohm feed-thru terminations to the Channel 1 and Channel 2 inputs of the Test Oscilloscope.

b. Connect a coaxial cable from the composite blanking output of the Type 4501 to Channel 1 input of the test oscilloscope. Connect a coaxial cable from the composite sync output of the Type 4501 to the Channel 2 input of the test oscilloscope.

c. Using a 10X probe, externally trigger the test oscilloscope (A triggering) from pin 19 of the read raster circuit board or pin 5 of J1304.

d. Set the test oscilloscope Channel 1 and Channel 2 Volts/Div switches to 2 volts, coupling to AC, and MODE to ALT.

e. Set up the test oscilloscope for delayed sweep, setting the Time/Div switch to 5 ms and the delay time to .2 ms.

f. Fig. 5-5A shows the display that should be on screen. Using the delayed sweep, expand the display and examine the vertical interval, horizontal blanking and horizontal sync in detail as illustrated in Fig. 5-5B and C.

g. Disconnect the 75 ohm attenuators, coaxial cables and 10X probe from the test oscilloscope and the Type 4501.

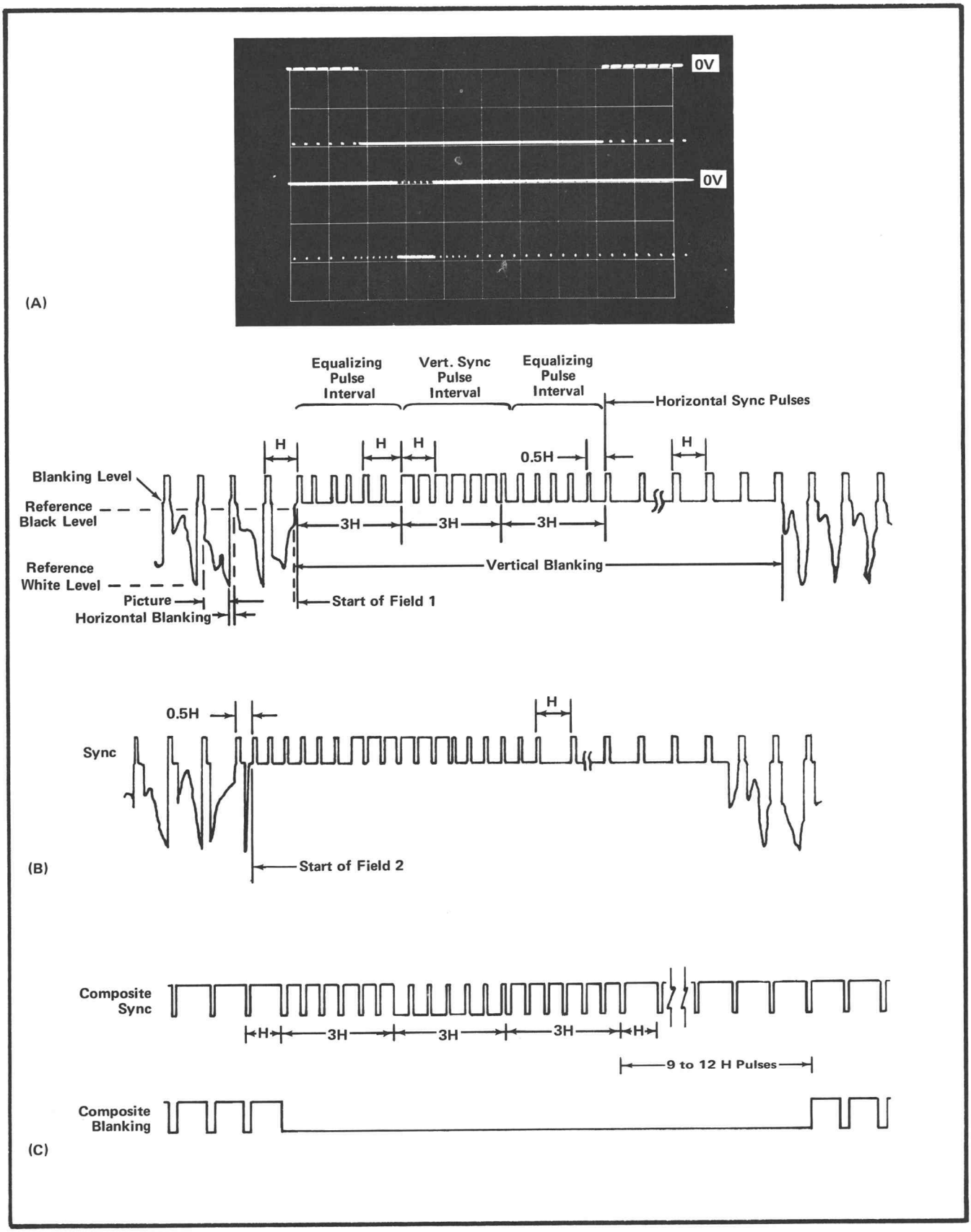


Fig. 5-5. A. Composite Sync and Composite Blanking as viewed on test oscilloscope. B. Field 1 and Field 2 illustration (FCC Regulations). C. Composite Sync and Composite Blanking vertical interval illustration.

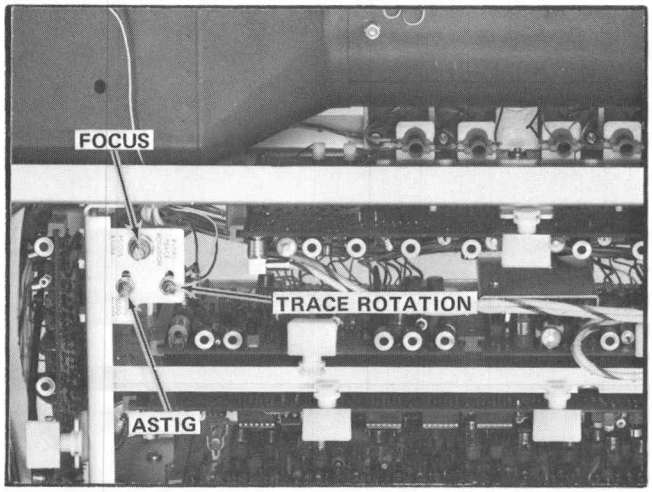


Fig. 5-6. Location of Focus, Astigmatism, and Trace Rotation adjustments.

7. Adjust Focus Astigmatism and Trace Rotation

a. While positioning the writing beam to the 4 quadrants of the storage CRT, adjust the focus control (R1084 and the astigmatism control) R1092 (see Fig. 5-6) for a well defined display.

b. Test equipment setup for the following steps is shown in Fig. 5-7.

c. Connect the sweep sawtooth attenuator text fixture into the test oscilloscope A sweep BNC connector. Connect a coaxial cable from the sweep sawtooth attenuator to the Type 4501 + X input. This produces a horizontal trace on the Type 4501 CRT.

d. Connect the + Gate attenuator text fixture into the test oscilloscope A + Gate BNC connector. Connect a coaxial cable from the Gate attenuator to the Type 4501 + Z Input. Adjust the Gate attenuator so the Type 4501 is blanked during re-trace (approximately 1 V into the Type 4501).

CAUTION

If sweep is not connected, the Z Axis pulse may cause phosphor burns. Remove Z Axis input before removing the X-Y inputs or turn INTENSITY control counterclockwise.

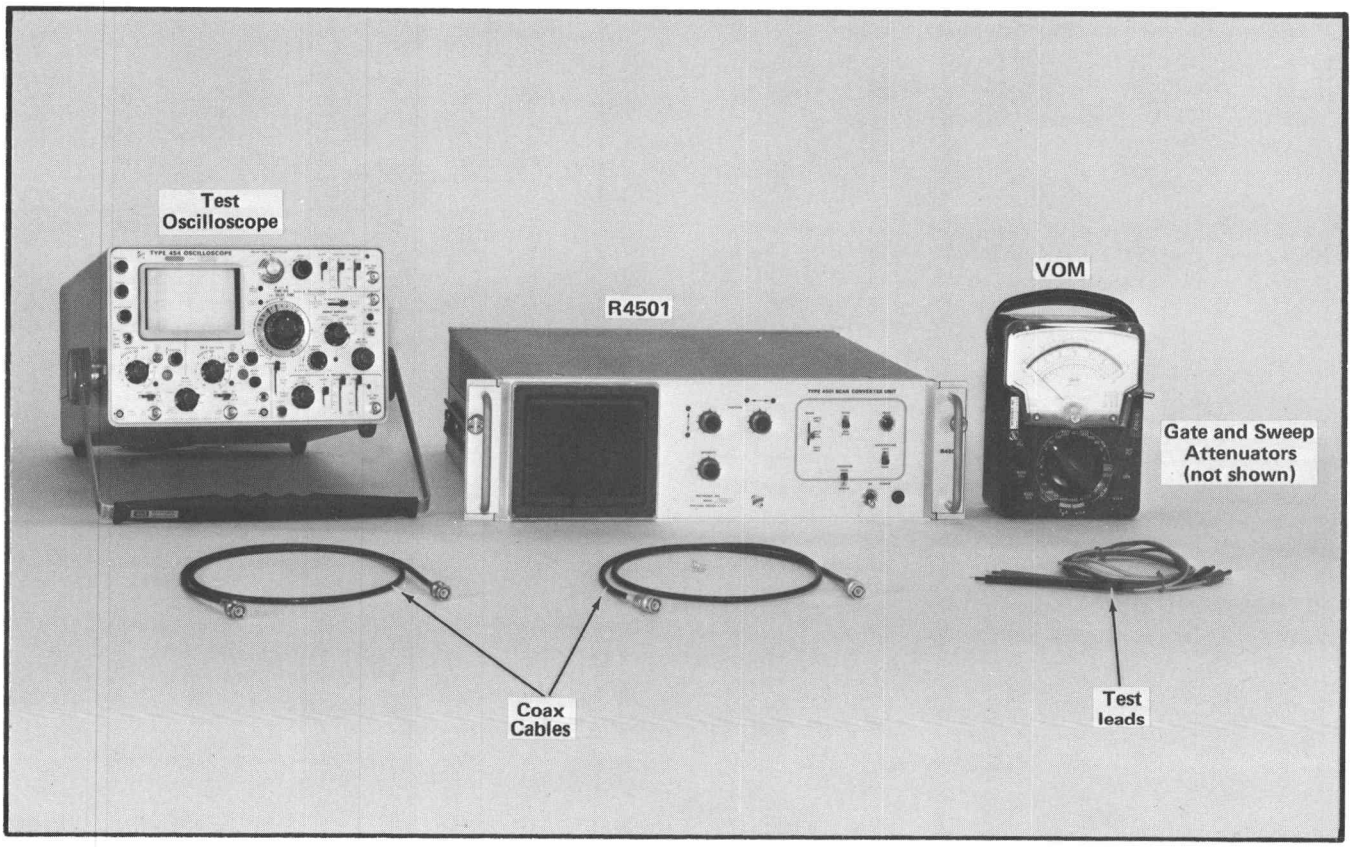


Fig. 5-7. Test equipment required for Storage calibration.

e. Using the Type 4501 Positioning Controls, position the start of the trace to the left edge of the storage CRT, centered vertically on the CRT.

f. Adjust the Sawtooth Sweep Attenuator until the horizontal trace is equal to the Type 4501 CRT width.

g. Adjust the Trace Rotation, R1090, (see Fig. 5-6) until the horizontal trace is parallel to the graticule lines.

STORAGE SYSTEM

Control Settings

Type 4501

INTENSITY	Nominal Brightness
STORE/NON-STORE MODE	NON-STORE WRITE AND READ

8. Check Operating Level Range

NOTE

If CRT performance has been satisfactory no adjustment of steps 8, 9 and 10 is necessary. Proceed to step 11. Storage tube voltages recommended for the CRT in this instrument are written on a tag fastened to the CRT shield. These voltages can be set using the adjustments shown in Fig. 5-9. The optimum value of the Store and Non-Store voltages tends to increase during the life of the CRT. The voltages given on the tag provide a good starting point at which to initially set the Storage adjustments.

a. Switch the Type 4501 Mode Switch to the WRITE ONLY position and the STORE/NON-STORE switch to the STORE position. Erase the storage CRT.

b. Connect a DC Voltmeter set to the 300 volt range between the target anode (see Fig. 5-8) and ground.

c. Record the voltmeter reading so that the operating level can be reset to this voltage after the range is checked.

d. Rotate the store STB Level, R644, (see Fig. 5-9) fully counterclockwise and note the voltmeter reading.

e. CHECK—Operating level (target to ground) is equal to or less than +100 volts.

f. Rotate the Store STB Level control fully clockwise, note the voltmeter reading and rotate the Store STB Level control counterclockwise.

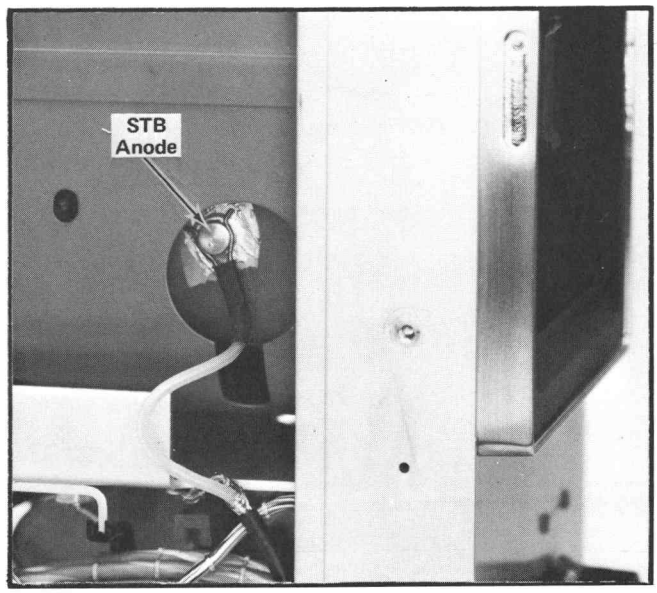


Fig. 5-8. Location of Target anode.

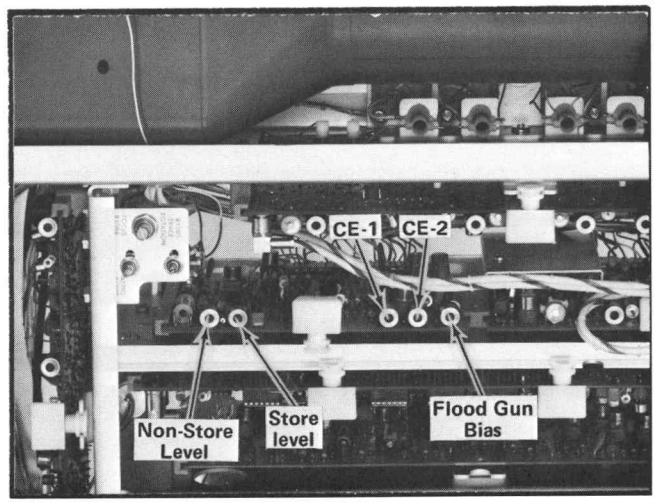


Fig. 5-9. Location of Storage adjustments.

g. CHECK—Operating level noted in step f is equal to or greater than +285 volts.

h. Push the erase button, then adjust the Store STB Level control to the voltage recorded in step c.

9. Adjust Operating Level

a. Locate writing threshold as follows:

(1) Press the ERASE button to prepare the target area for storage.

(2) Set the test oscilloscope to single sweep, the Time/Div switch to .5 ms, and adjust the Type 4501 intensity control for nominal brightness.

(3) Write approximately 3 lines per centimeter on the target area by depressing the test oscilloscope Reset. After each line is written, change the vertical position before writing the next trace.

(4) Carefully check the written lines for breaks or gaps of 0.025 inches or more. If no breaks or gaps are evident after 10 seconds, note the voltmeter reading and adjust the Store STB Level control to reduce the operating level by 5 volts.

(5) Erase twice, wait 10 seconds, then write again and check for breaks or gaps.

(6) Repeat this procedure of decreasing the operating voltage level in 5 volt steps until breaks of approximately 0.025 inches occur. This is the Writing Threshold. Note this voltage and adjust the Store STB Level control until the original level noted in step 4 is reached.

NOTE

Do not change the INTENSITY, Focus or Astigmatism control settings.

b. Locate the upper writing limit as follows:

(1) Press the erase button to prepare the target area for storage.

(2) Write approximately 3 lines per centimeter on the target area by pressing the test oscilloscope reset button down to the reset position. After each line is written, change the vertical position before writing the next trace.

(3) Carefully check the stored lines and background for trace spreading of about 0.025 inches or background fade-up. If no trace spreading or background fade-up is evident after 10 seconds, adjust the Store STB Level controls to increase the operating level by 5 volts.

(4) Erase twice, wait ten seconds, then write again and check for spreading or fade-up.

(5) Repeat this procedure until trace spreading of approximately 0.025 inches or background fade up occurs. This is the upper writing limit. Note this voltage.

c. Adjust the Store STB Level control for an operating point midway between the writing threshold and upper writing limit.

d. Disconnect the DC Voltmeter.

e. INTERACTION—Check Collimation and X-Y Gain.

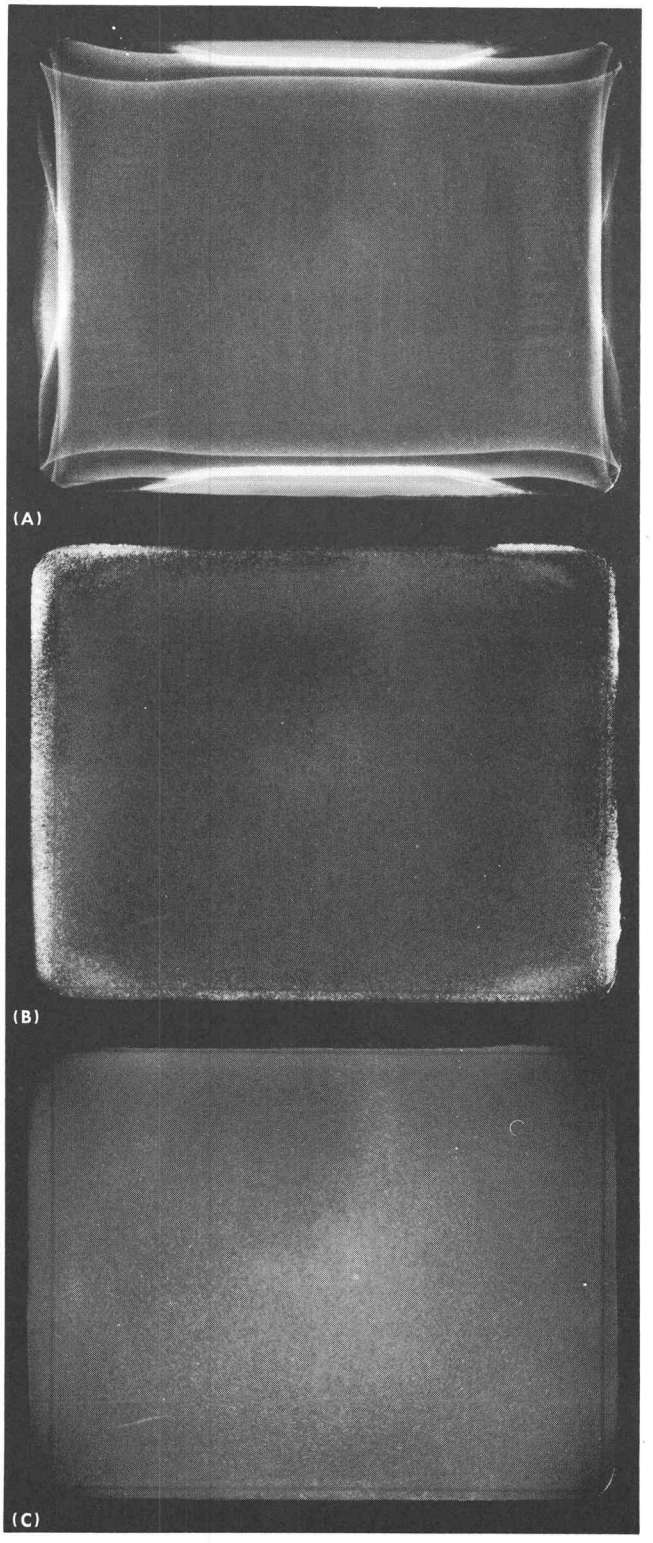


Fig. 5-10. A. and B. Collimation misadjusted. C. Collimation adjusted for optimum brightness.

10. Adjust Collimation and Flood Gun Grids

a. Return the test oscilloscope A Sweep Mode Switch to Norm.

b. Adjust the Type 4501 INTENSITY CONTROL for a sweep of nominal brightness. Then write the entire screen by positioning the trace vertically with the vertical position control. If the screen fails to write, slightly adjust the intensity control clockwise and repeat the process until the screen is fully written.

c. Return the trace to the bottom graticule line and set the test oscilloscope A Sweep Mode to single sweep to turn off the Type 4501 CRT beam.

d. With the screen fully written, rotate the flood gun bias control R692 (see Fig. 5-9) fully counterclockwise. Note the shadows around the edges of the screen.

e. Slowly rotate the flood gun bias control clockwise until the shadows just disappear; then rotate the control another 10 degrees clockwise past this point.

f. With the storage CRT fully written rotate CE-1, R687, (see Fig. 5-9) counterclockwise until the background appears to pull in. Now rotate the adjustment for CE-1 clockwise until a bright spot appears in the center of the CRT, and then rotate slightly counterclockwise until the bright spot just disappears. This should set the voltage at CE-1 to about +90 volts.

g. While erasing rotate CE-2, R682, (see Fig. 5-9) clockwise until the edge of the CRT fades positive. Now rotate the CE-2 adjustment counterclockwise until the edge lighting just disappears. Fig. 5-10 illustrates the effect of correct and incorrect adjustment of collimation voltages.

h. INTERACTION—Collimation affects vertical and horizontal gain, linearity and storage capabilities.

11. Adjust Nonstore Level

a. Return the test oscilloscope A Sweep Mode Switch to Norm Trigger. Set the Type 4501 STORE/NON-STORE switch to NON-STORE. Erase the storage CRT.

b. Using the vertical position control, continuously move the trace up and down on the CRT. Simultaneously rotate the non-store level adjustment, R645, (see Fig. 5-9) clockwise until the CRT begins to store portions of the trace. Then rotate the non-store level adjust counterclockwise just past the storage point for no storage.

NOTES

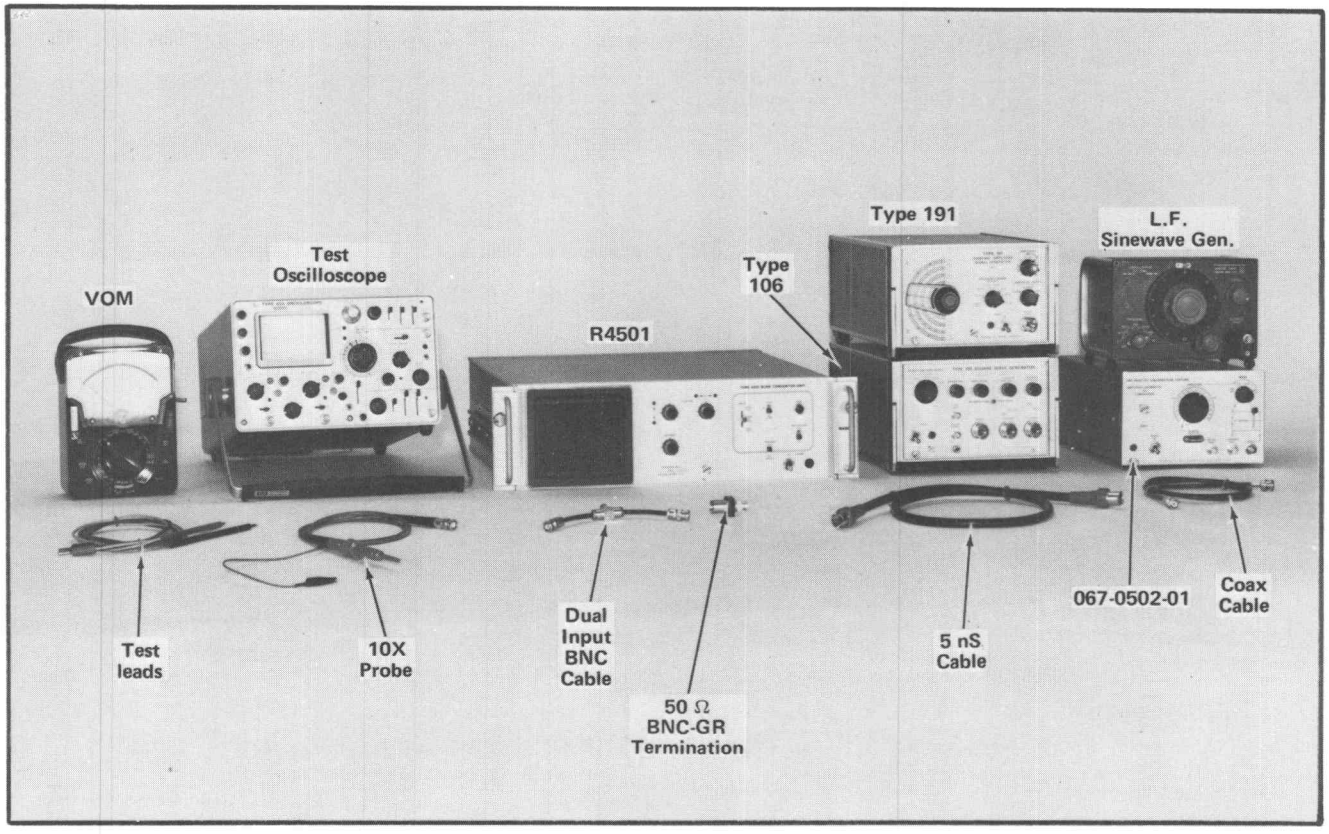


Fig. 5-11. Test equipment required for Z Axis calibration.

Z-AXIS AMPLIFIER

12. Adjust Z DC Bal and DC Level

a. Test equipment required is shown in Fig. 5-11. Be sure that shorting cap is connected to the –Z input.

b. Disconnect all signals into the Type 4501. Set the Type 4501 MODE switch to WRITE ONLY, the STORE/NON-STORE switch to NON-STORE. Set the Limiting switch (internal switch located on the Z-axis board, See Fig. 5-12) to the Linear mode.

c. Connect a 10X probe from the test oscilloscope to pin 11 on the Z-axis board, DC couple the test oscilloscope. Using the front panel INTENSITY control, set the voltage to 0 V as monitored on the test oscilloscope and maintain this level throughout step 12.

d. With the DC voltmeter monitoroing the voltage at pin S (approximately +17 VDC), adjust R223 (Z DC Bal), see Fig. 5-13, for minimum shift of DC level while rotating R236 (Z Gain) from fully clockwise to fully counter-clockwise.

e. If necessary, readjust the INTENSITY control, for a 0 V indication, as in step (c.) above.

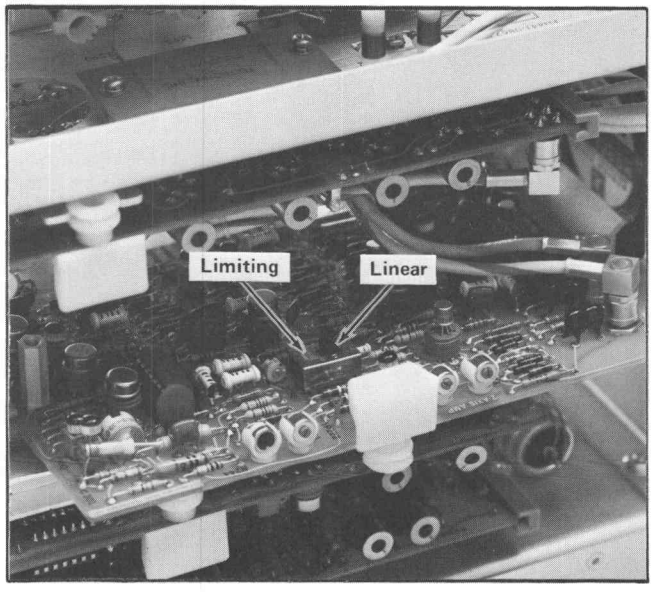


Fig. 5-12. Location of Linear/Limiting switch.

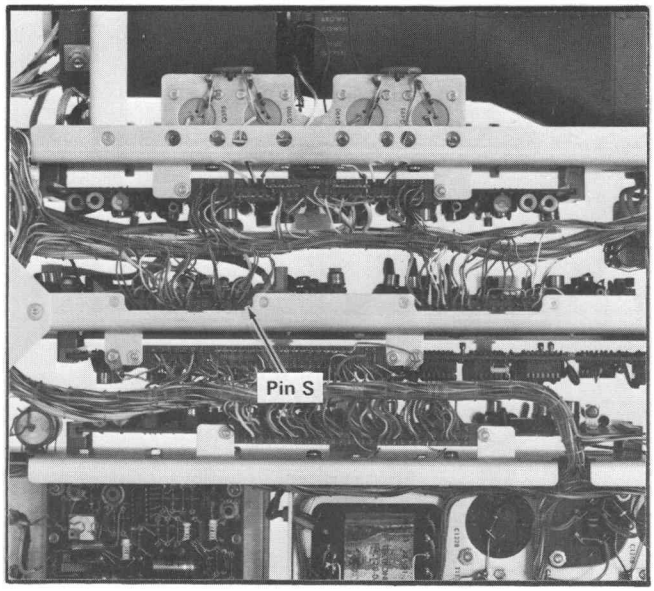


Fig. 5-13. Location of Pin S, Z Axis board.

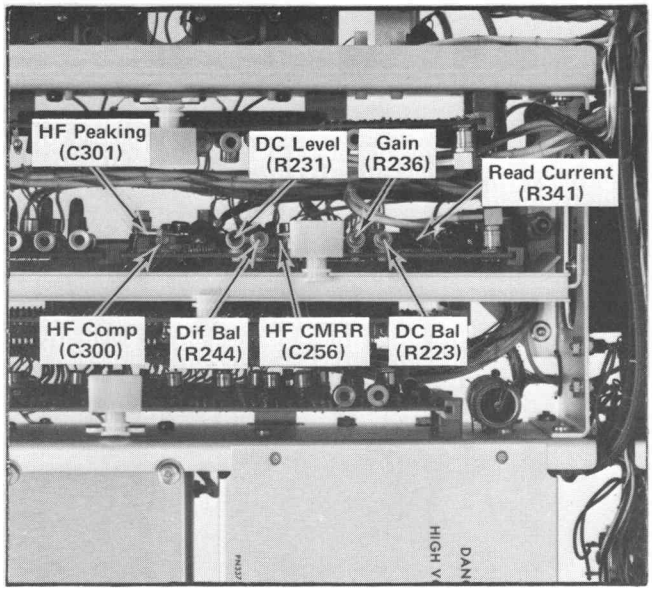


Fig. 5-14. Location of Z Axis adjustments.

f. Disconnect the voltmeter from pin S and connect it to TP222. Set the DC Level Adjustment (R231) for zero volts at TP222.

g. Recheck the DC Balance as given in step (d.) above.

h. Disconnect the DC voltmeter from the Z-Axis board.

13. Check/Adjust Amplifier Gain (R236)

a. Connect the 10X probe from the test oscilloscope Channel 1 input to pin S of the Z-axis amplifier board. Set the test oscilloscope to Auto trigger and the Channel 1 input to AC coupled. Set the test oscilloscope Volts/Div switch to .5 volts.

b. Connect a coaxial cable from the Amplitude Calibrator Output connector to the +Z input of the Type 4501. Set the output amplitude of the Amplitude Calibrator for .5 volts and set the MODE switch for a square wave output.

c. Check for a peak-to-peak output at pin S of 18 V to 22 V.

d. ADJUST—Z Gain, R236, (see Fig. 5-14) for a peak-to-peak output at pin S of 20 V.

14. Check/Adjust Low Frequency CMRR

a. Disconnect the shorting cap from the Type 4501 —Z input. Connect the BNC dual input connector to the + and —Z inputs.

b. Connect a coaxial cable from the General Radio Low Frequency Sine-wave generator output connector to the Channel 2 input of the test oscilloscope. Set the output frequency of the low frequency sine wave generator for 10 kHz and set the output level for 5 volts peak-to-peak as displayed on the test oscilloscope. Disconnect the coaxial cable from the Channel 2 input of the test oscilloscope and connect it to the BNC dual input connector on the Type 4501.

c. CHECK—The output, pin S of the Z-axis amplifier, should be less than 0.4 volts as displayed on the test oscilloscope.

d. ADJUST—Z Dif Bal, R244, (see Fig. 5-14) for minimum output (as displayed on the test oscilloscope) less than 0.4 volts.

e. Disconnect the BNC dual input connector from the Type 4501 and connect the shorting cap to the —Z input.

15. Check/Adjust Transient Response

a. Connect the 5 ns cable to the + Fast Rise Output of the Type 106 Square Wave Generator and set the amplitude of the output waveform to 0.5 volts (use test oscilloscope to obtain correct amplitude). Set the output frequency of the Type 106 for 200 kHz. Connect a BNC to GR 50 ohm feedthrough terminator to the 5 ns cable. Connect the 50 ohm terminator to the +Z input of the Type 4501.

b. Set the test oscilloscope Volts/Div switch to .5 volts and set the Time/Div switch for .5 μs and the Horizontal

Display Mag switch to X10. Adjust the INTENSITY control so that the observed signal (approximate 20 V amplitude) is centered near the center of the Z Axis Amplifier range.

c. CHECK—The aberrations are within 5% of pulse amplitude as displayed on the test oscilloscope (less than 2 millimeters).

d. ADJUST—C300, C301 (see Fig. 5-14) for optimum square corner of the displayed waveform; aberrations within 5% of displayed waveform amplitude.

16. Check Z Axis Bandwidth

a. Disconnect the 5 ns cable from the Type 106 Square Wave Generator and connect it to the output of the Type 191 Constant Amplitude Signal Generator. Set the Type 191 frequency range to 50 kHz only position. Set the Type 191 amplitude for .5 volts out. (A 20 volt peak-to-peak display on the test oscilloscope.) This is the reference voltage for checking bandwidth. Readjust the 4501 Intensity to set the observed signal near the center of the Z Axis Amplifier range.

b. Set the Type 191 for an output frequency of 5 MHz.

c. CHECK—The test oscilloscope display must be equal to or greater than 14.1 volts peak-to-peak.

d. If the bandwidth requirement is not met, repeat step 16.

17. Check/Adjust Common Mode Rejection Ratios

a. Disconnect the 50 ohm BNC to GR connector from the Type 4501, and connect the BNC dual input cable to the 50 ohm feedthrough terminator. Disconnect the shorting cap from the −Z input and connect the BNC dual input cable to the + and −Z inputs. Set the Type 191 frequency output to 5 MHz and the amplitude for 5 volts.

b. CHECK—The CMRR should be equal to or less than 20 volts peak to peak as displayed on the test oscilloscope.

c. Set the Type 191 frequency output to 1 MHz.

d. CHECK—The CMRR should be equal to or less than 2 volts P-P as displayed on the test oscilloscope.

e. Disconnect the 50 ohm terminator from the dual input BNC connector. Connect a coaxial cable from the dual input connector to the output connector on the General Radio Low Frequency Sine-Wave Generator. Set the low frequency sine wave generator for an output frequency of 10 kHz and the output level for 5 volts peak to peak (use test oscilloscope to obtain 5 volt level).

f. CHECK—The test oscilloscope display should be equal to or less than 0.4 volts peak to peak for a CMRR of 500 to 1.

g. ADJUST—If the 1 MHz and/or 5 MHz CMRR is not within specs, adjust C256 to make the specified CMRR.

h. Disconnect the BNC dual input cable from the + and −Z inputs of the Type 4501. Connect the shorting cap to the −Z input.

18. Check Limiting

a. Connect a coaxial cable from the +Z input to the output connector on the Amplitude Calibrator and Comparator. Set the Amplitude Calibrator for 0.5 volts, Chopped, and +DC.

b. Switch the Linear/Limiting switch (see Fig. 5-12) located on the Z axis amplifier board to the Limiting position.

c. CHECK—The test oscilloscope display for no output. Set the Amplitude Calibrator output to 1 volt and check the test oscilloscope display for a 60 Hz square-wave output from pin S of the Z axis amplifier board. It may be necessary to adjust Gain (R236) to satisfy both conditions of this step but gain setting must be within ±10% of the value called for in step 13d.

d. Disconnect the coaxial cable from the +Z input and the shorting cap from the −Z input. Connect the coaxial cable to the −Z input and the shorting cap to the +Z input.

e. Switch the Amplitude Calibrator to −DC and repeat step c.

f. Disconnect the signal from the −Z input and return the Linear/Limiting switch to the Linear position and the shorting cap to the −Z input.

g. Switch to READ ONLY.

h. Ground TP272 and check read pulse amplitude of +18 V ±2.5 V.

i. Remove the ground from TP272 and the 10X probe.

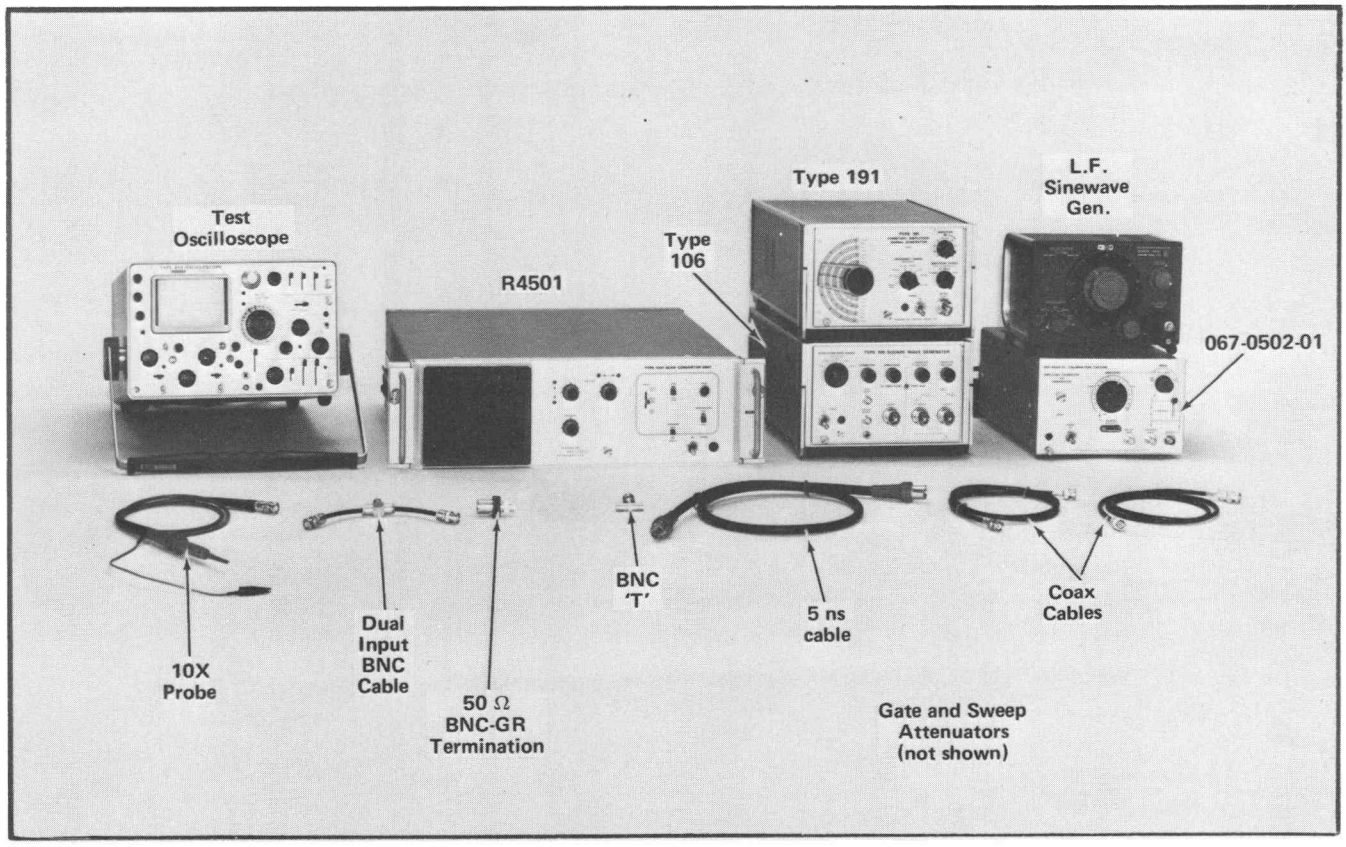


Fig. 5-15. Test equipment required for X-Y Axis calibration.

X AND Y AMPLIFIERS

19. Check/Adjust X-Y Gain and Positioning

a. Test equipment required is shown in Fig. 5-15.

b. Set the Type 4501 mode switch to the WRITE AND READ position. Set the STORE/NON-STORE switch to the NON-STORE position.

c. CHECK—The raster display on the Type 4501 CRT is 7.5 cm vertically, centered on the CRT graticule.

d. ADJUST—R562 (see Fig. 5-16) until the raster amplitude is 7.5 cm. Center the raster on the CRT graticule by adjusting R85, Vertical Ramp Position (see Fig. 5-17).

e. CHECK—The raster is 10 cm horizontally, centered on the CRT graticule.

f. ADJUST—R462, X gain, (see Fig. 5-20) for 10 cm of displayed raster and adjust R55, Horizontal Ramp Position, (see Fig. 5-17) to center the raster horizontally on the CRT graticule.

20. Check/Adjust Y Position Center

a. Switch the Type 4501 MODE switch to the WRITE ONLY position.

b. Connect the Sweep and Blanking pulse to the Type 4501 as described in step 7c and d.

c. Connect a 10X probe from the test oscilloscope to pin EE of the X-Y amplifier board (vertical Position control center arm) see Fig. 5-18. DC couple the test oscilloscope. Using the front panel Vertical Position control, set the voltage to 0 V as monitored on the test oscilloscope. Maintain this level through steps 20 and 21.

d. CHECK—The trace should be centered vertically on the CRT graticule.

e. ADJUST—R549, Y position center, (see Fig. 5-16) until the trace is centered vertically on the CRT graticule.

21. Adjust Y DC Bal

a. ADJUST—DC Bal, R508, (see Fig. 5-16) for minimum shift of trace while varying Y Write Sens, R538, (see Fig. 5-16) from fully clockwise to fully counterclockwise.

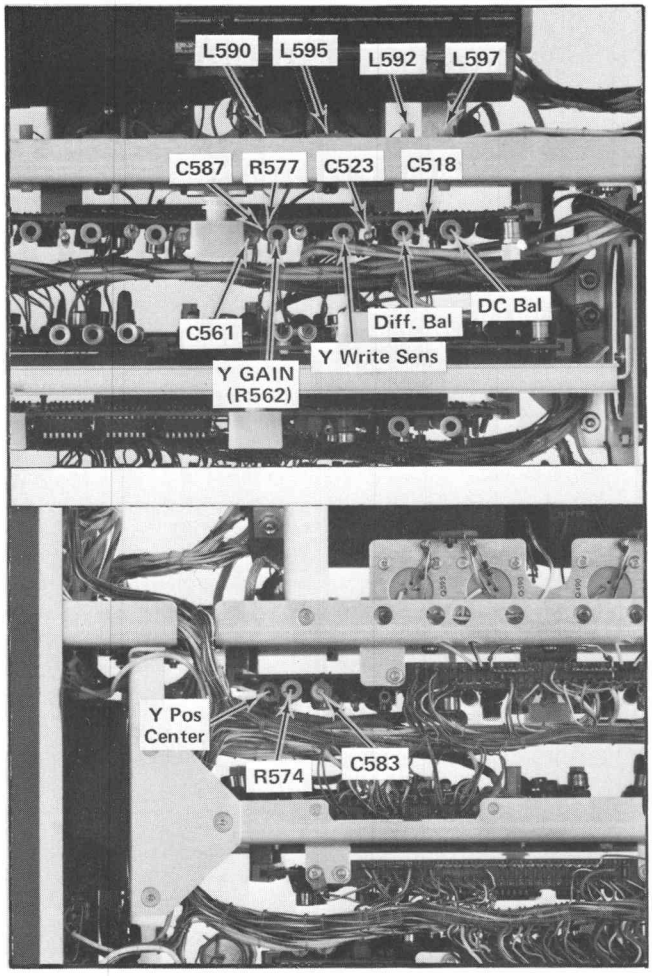


Fig. 5-16. Location of Y Axis Adjustments.

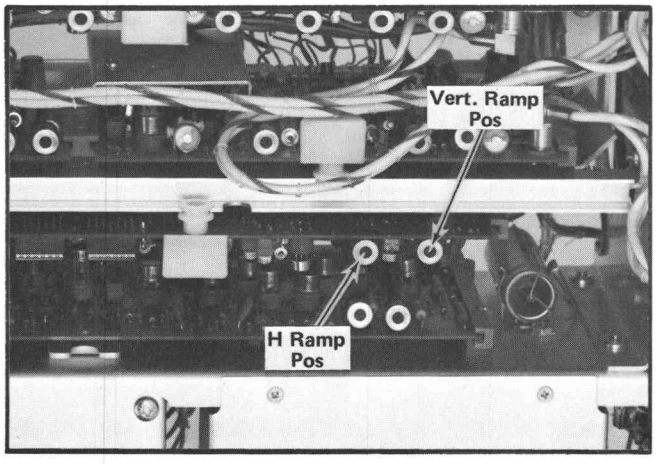


Fig. 5-17. Location of Vertical ramp position and Horizontal ramp position adjustments.

b. Recenter the trace vertically on the CRT graticule by readjusting Y Position Center, R548.

c. Disconnect the 10X probe from pin EE.

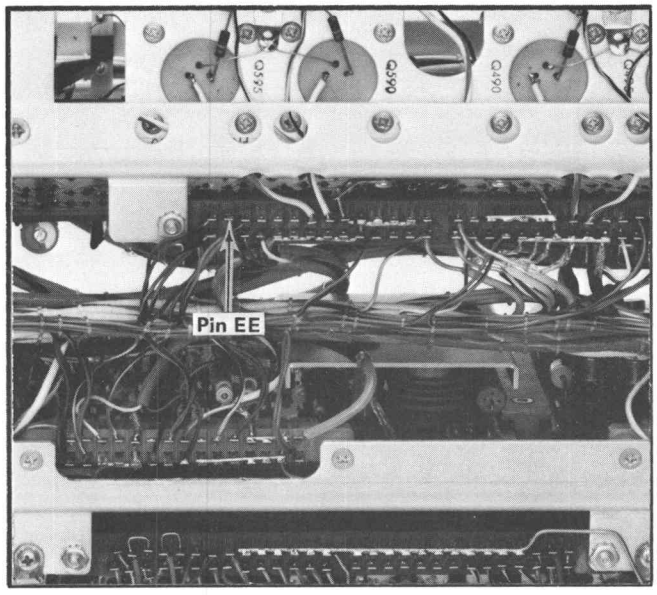


Fig. 5-18. Location of Pin EE, X-Y Axis board.

22. Check/Adjust Y Write Sens

a. Connect a coaxial cable from the Amplitude Calibrator Output connector to the +Y BNC connector on the Type 4501. Be sure that the shorting caps are connected to the –X, –Y and –Z inputs.

b. Set the Amplitude Calibrator Mode switch to select the square wave output and set the Amplitude to .5 V.

c. CHECK—The Type 4501 display should be 5 cm vertically.

d. ADJUST—Y Write Sens, R538, for 5 cm of display on the Type 4501 CRT.

e. Disconnect the coaxial cable from the +Y input.

23. Adjust Y Diff Bal

a. Remove the shorting cap from the Type 4501 –Y input and connect the BNC dual input cable to the + and –Y inputs. Connect a 50 Ω feedthrough terminator (BNC to GR) to the dual input cable.

b. Connect a 5 ns cable to the output connector on the Type 191 Constant Amplitude Signal Generator. Connect the other end of the 5 ns cable to the 50 Ω feedthrough terminator. Set the Type 191 frequency range to 50 kHz only position; set the 191 Amplitude to 50. Set the 191 Amplitude Range Control to .5-5 volt position.

c. ADJUST–The Y Diff Bal, R520, (see Fig. 5-16) for minimum deflection.

d. INTERACTION–Steps 22 and 23 interact. Repeat as necessary.

e. Disconnect the BNC dual input cable from the + and – Y inputs. Connect the shorting cap to the – Y input.

24. Adjust Transient Response

a. Connect the BNC to GR 50 Ω feedthrough terminator to the +Y input. Connect the 5 ns cable from the 50 Ω terminator to the Fast Rise + Output of the Type 106 Square Wave Generator. Connect a coaxial cable from the Type 106 Trigger Output connector to the external trigger input connector of the test oscilloscope and trigger the test oscilloscope on external trigger. Set the test oscilloscope Time/Div switch .2 μs. Set the Type 106 Repetition Rate Range to 1 MHz. Set the Type 106 Transition Amplitude for the + output to display 4 cm on the Type 4501.

b. Adjust the test oscilloscope triggering level for a stable display on the Type 4501.

c. CHECK–The leading corner of the positive going square-wave displayed on the Type 4501 for less than 2 mm of aberrations. Disconnect the signal from the + input and connect it to the – input. Check the – input in the same manner as the + input.

d. ADJUST–C561, R574, C583, R577, C587, L590, L595, L592, L597, C523, and C518, (see Fig. 5-16) for a square leading corner with fast rise and less than 2 mm of aberrations. These controls should be adjusted in small increments in the order given. L590 and L595 should be adjusted to approximately the same depth. L592 and L597 should also be adjusted to approximately the same depth.

25. Check Bandwidth

a. Disconnect the 5 ns cable from the Type 106 and connect it to the output connector on the Type 191 Constant Amplitude Signal Generator. Set the Type 191 frequency range to 50 kHz only position. Adjust the Type 191 amplitude for 7.5 cm of display on the Type 4501. The 7.5 cm area is represented by the dashed lines across the top and bottom of the CRT graticule.

b. Change the Type 191 Frequency Range Control to the 8 to 18 MHz position. Set the Type 191 frequency to 10 MHz.

c. CHECK–The Type 4501 display should be less than 3 dB down. The 3 dB point is represented by the solid line (approximately 3/8 inch in length) across the top and bottom of the center graticule line. Disconnect the signal from the + input and connect it to the – input. Check the – input in the same manner as the + input.

d. If the bandwidth requirement is not met, repeat high frequency compensation, step 24.

e. The risetime can be computed from the following formula: $\text{Risetime} = \frac{.35}{\text{bandwidth}}$

26. Check/Adjust High Frequency CMRR

a. Disconnect the 50 Ω feedthrough terminator from the + input of the Type 4501 and connect the Dual Input Connector to the 50 Ω terminator. Disconnect the shorting cap from the –Y input and connect the dual input cable to the + and –Y inputs of the Type 4501.

b. Set the Type 191 frequency to 10 MHz and set the amplitude for 5 volts peak to peak output.

c. CHECK–The Type 4501 display is equal to or less than 5 cm. This indicates a common mode rejection ratio of 10 to 1 or greater.

d. ADJUST–C518 and C523 if common mode rejection is not met. If adjustment is required, a practical approach is to turn one capacitor clockwise and one capacitor counterclockwise in 1/2 turn increments to maintain front corner compensation.

e. INTERACTION–Steps 24, 25 and 26 interact.

f. Set the Type 191 frequency to 1 MHz.

g. CHECK–The Type 4501 display is equal to or less than .5 cm.

27. Check Low Frequency Common Mode Rejection

a. Disconnect the 50 Ω terminator from the dual input BNC cable. Connect a BNC T connector to the General Radio Sine Wave Generator Output Connector. Connect a coaxial cable from the BNC T connector to the BNC dual input cable on the Type 4501. Connect a coaxial cable from the T connector to the Channel 1 input connector on the test oscilloscope.

b. Set the General Radio Sine Wave Generator for an output frequency of 10 kHz. While monitoring the output amplitude on the test oscilloscope, set the sine wave generator output level for 5 V.

c. CHECK—The Type 4501 display for equal to less than 1 mm of display. This indicates a CMRR of 500 to 1.

d. If CMRR is not met, repeat steps 23 through 26.

e. Disconnect the sine wave generator from the Type 4501 and the test oscilloscope.

28. Check/Adjust X Position Center

a. Disconnect the Sweep in from the +X input and connect it to the +Y input.

b. Connect a 10X probe from the test oscilloscope to pin B of the X-Y amplifier board (Horizontal Position control center arm) see Fig. 5-19. DC couple the test oscilloscope. Using the front panel Horizontal Position control, set the voltage to 0 V as monitored on the test oscilloscope. Maintain this level through steps 28 and 29.

c. CHECK—The trace should be centered horizontally on the CRT graticule.

d. ADJUST—R449, X Position Center, (see Fig. 5-20) until the trace is centered horizontally on the CRT graticule.

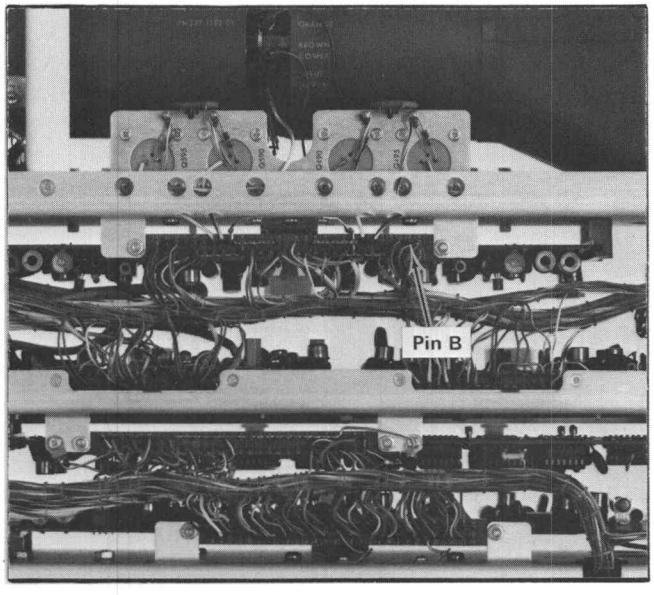


Fig. 5-19. Location of Pin B on X-Y board.

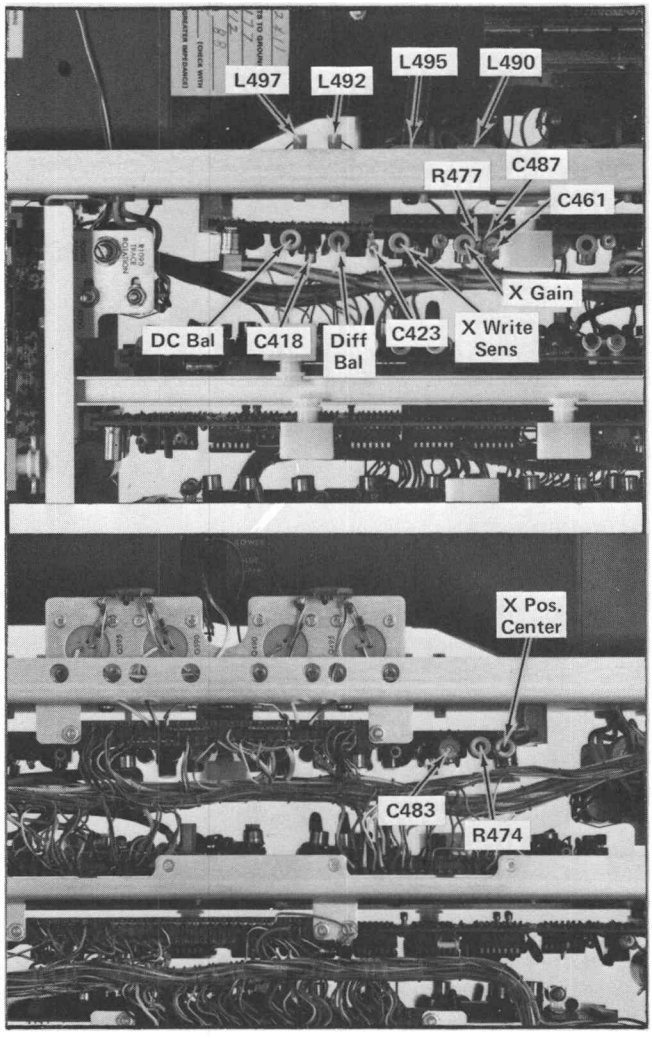


Fig. 5-20. Location of X Axis adjustments.

29. Adjust X DC Bal

a. ADJUST—DC Bal, R408, (see Fig. 5-20) for minimum shift of trace while varying X Write Sens, R438, (see Fig. 5-20) from fully clockwise to fully counterclockwise.

b. Recenter the Trace horizontally on the CRT graticule by readjusting X Position Center, R449.

c. Disconnect the 10X probe from pin B.

30. Check/Adjust X Write Sens

a. Connect a coaxial cable from the Amplitude Calibrator Output connector to the +X BNC connector on the Type 4501. Insure that the shorting caps are connected to the −X, −Y and −Z inputs.

b. Set the Amplitude Calibrator Mode switch to select the square wave output and set the amplitude to .5 V.

c. CHECK—The Type 4501 display should be 5 cm horizontally.

d. ADJUST—X Write Sens, R438, for 5 cm of display on the Type 4501 CRT.

e. Disconnect the coaxial cable from the +X input.

31. Adjust X Diff Bal

a. Remove the shorting cap from the Type 4501 —X input and connect the BNC dual input cable to the + and —X inputs. Connect a 50 Ω feedthrough terminator (BNC to GR) to the dual input cable.

b. Connect a 5 ns cable to the output connector on the Type 191 Constant Amplitude Signal Generator. Connect the other end of the 5 ns cable to the 50 Ω feedthrough terminator. Set the Type 191 frequency range to 50 kHz only position, and the 191 amplitude to 50. Set the 191 amplitude range control to .5—5 volt position.

c. ADJUST—The X Diff Bal, R420, (see Fig. 5-20) for minimum deflection.

d. INTERACTION—Steps 30 and 31 interact. Repeat as necessary.

e. Disconnect the BNC dual input cable from the + and —X inputs. Connect the shorting cap to the —X input.

32. Adjust Transient Response

a. Connect the BNC to GR 50 Ω terminator to the +X input. Connect the 50 ns cables from the 50 Ω terminator to the Fast Rise + Output of the Type 106 Square Wave Generator. Connect a coaxial cable from the Type 106 Trigger Output Connector to the external trigger input connector of the test oscilloscope and trigger the test oscilloscope on external trigger. Set the test oscilloscope Time/Div switch to .2 μs. Set the Type 106 Repetition Rate Range to 1 MHz. Set the Type 106 Transition Amplitude, for the + output, to display 4 cm on the Type 4501.

b. Adjust the test oscilloscope triggering level for a stable display on the Type 4501.

c. CHECK—The leading corner of the positive going square-wave displayed on the Type 4501 for less than 2 mm of aberrations. Disconnect the signal from the + input and connect it to the — input. Check the — input in the same manner as the + input.

d. ADJUST—C461, R474, C483, R477, C487, L490, L495, L492, L497, C423, and C418, (see Fig. 5-20) for a square leading corner with fast rise and less than 2 mm of aberrations. These controls should be adjusted in small increments in the order given. L490 and L495 should be adjusted to approximately the same depth, L492 and L497 should also be adjusted to approximately the same depth.

33. Check Bandwidth

a. Disconnect the 5 ns cable from the Type 106 and connect it to the output connector on the Type 191 Constant Amplitude Signal Generator. Set the Type 191 frequency range to 50 kHz only position. Adjust the Type 191 amplitude for 7.5 cm of display on the Type 4501. The 7.5 cm area is represented by the dashed lines across the left and right edges of the CRT graticule.

b. Change the Type 191 Frequency Range Control to the 8 to 18 MHz position. Set the Type 191 frequency to 10 MHz.

c. CHECK—The Type 4501 display should be less than 3 dB down. The 3 dB point is represented by the solid line (approximately 3/8 inch in length) across the left and right edges of the center graticule line. Disconnect the signal from the + input and connect it to the — input. Check the — input in the same manner as the + input.

d. If the bandwidth requirement is not met, repeat high frequency compensation, step 32.

e. The risetime can be computed from the following formula: $\text{Risetime} = \frac{.35}{\text{bandwidth}}$

34. Check/Adjust High Frequency CMRR

a. Disconnect the 50 Ω feedthrough terminator from the + input of the Type 4501 and connect the BNC dual input connector to the 50 Ω terminator. Disconnect the shorting cap from the —X input and connect the dual input cable to the + and —X inputs of the Type 4501.

b. Set the Type 191 frequency to 10 MHz and set the amplitude for 5 volts peak to peak output.

c. CHECK—The Type 4501 display is equal to or less than 5 cm. This indicates a common mode rejection ratio of 10 to 1 or greater.

d. ADJUST—C418 and C423 if common mode rejection is not met. If adjustment is required, a good practice is to turn one capacitor clockwise and one capacitor counter-clockwise in 1/2 turn increments to maintain front corner compensation.

e. INTERACTION—Steps 32, 33 and 34 interact.

f. Set the Type 191 frequency to 1 MHz.

g. CHECK—The Type 4501 display is equal to or less than .5 cm.

35. Check Low Frequency Common Mode Rejection

a. Disconnect the 50 Ω terminator from the dual input BNC cable. Connect a BNC T connector to the General Radio Sine Wave Generator Output Connector. Connect a coaxial cable from the BNC T connector or the BNC dual input cable on the Type 4501. Connect a coaxial cable from the T connector to the Channel 1 input connector on the test oscilloscope.

b. Set the General Radio Sine Wave Generator for an output frequency of 10 kHz. While monitoring the output amplitude on the test oscilloscope, set the sine wave generator output level for 5 V.

c. CHECK—The Type 4501 display for equal to or less than 1 mm of display. This indicates a CMRR of 500 to 1.

d. If the CMRR requirement is not met, repeat steps 31 through 34.

e. Disconnect the sine wave generator from the Type 4501 and the test oscilloscope.

NOTES

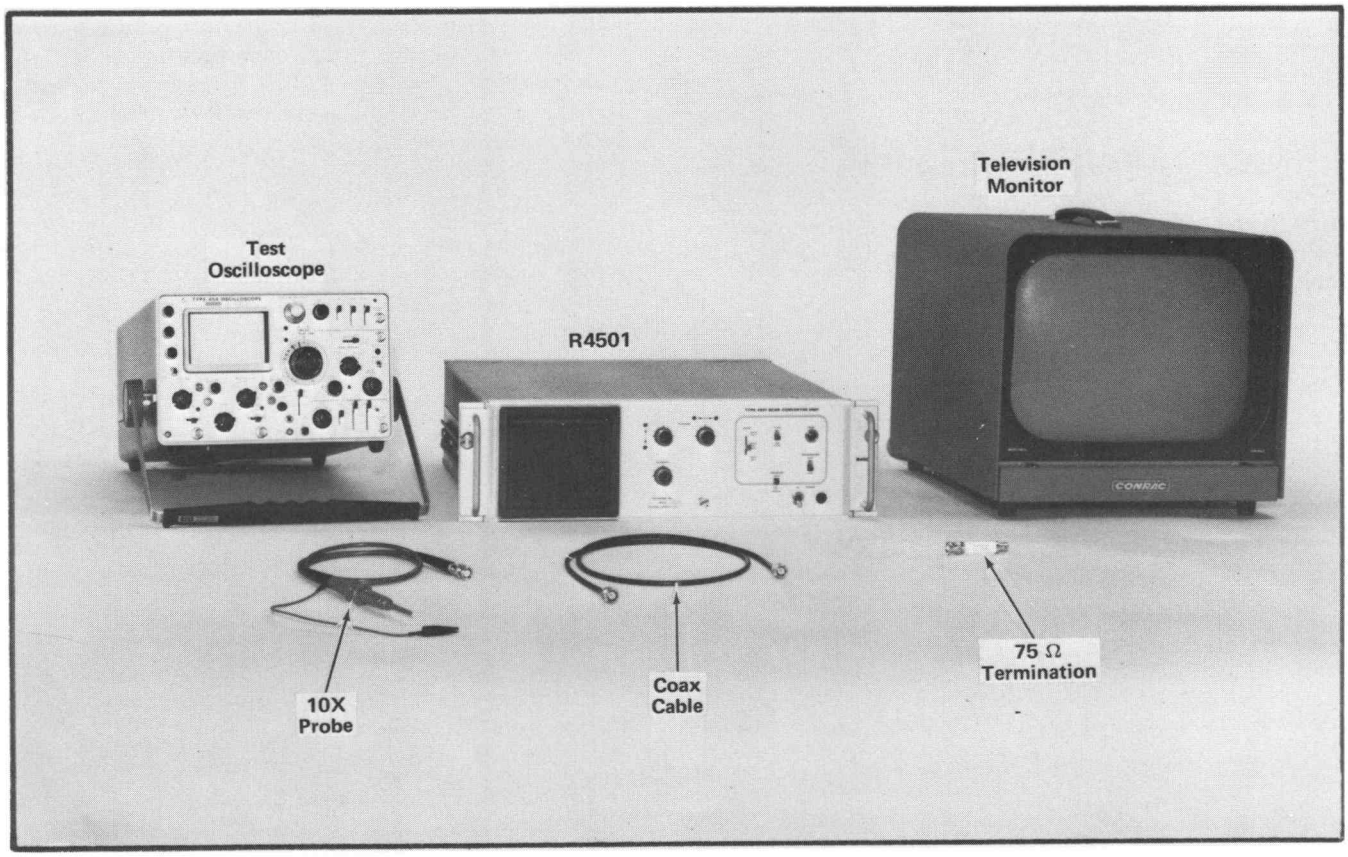


Fig. 5-21. Test equipment required for Read Amplifier and Modulator calibration.

READ AMPLIFIER

36. Check/Adjust Video Amplitude and Level

a. Test equipment required is shown in Fig. 5-21.

b. Verify steps 18g and 18h. Retain ground on TP272 to disable the CRT READ Current Regulator during the following steps. Maintenance of proper and constant video amplitude depends upon Z Axis Amplifier output level during Read Time, and is determined by the settings of the Intensity (R1066) and Read Current (R341) adjustments.

c. Connect the 10X probe to TP765.

NOTE

Use a short ground lead for the 10X probe. A 5 k resistor may be required in series with the probe tip to prevent Read Amplifier oscillations.

Proper video signals at TP765 are shown in Fig. 5-22 for the LIGHT and DARK positions of the BACKGROUND switch. The DC level of the video background and the video signal amplitude are the two important characteristics to verify.

d. Adjust R746 (Background Offset in Fig. 5-23) to obtain inverting video signals with their background levels at about -0.6 V (DARK) and +1.2 V (LIGHT). The average of these two levels is slightly positive (about 0.4 volts). In Fig. 5-22 the curvature of the background level is a result of an incorrect shading adjustment. The Cancel Balance is also misadjusted. Setting the Shading and the Cancel Balance adjustments is explained later in this procedure. If background level curvature is present, determine the background level at either end of the curved portion or visualize the level with the curvature removed.

e. Adjust R1066 (Intensity in Fig. 5-24) for a video amplitude of about 1.5 V.

f. Repeat steps (d) and (e), as necessary, for proper background level and video amplitude.

g. Remove the ground from TP272 to enable the CRT READ Current Regulator circuit to re-establish a video amplitude of 1.5 V as shown in Fig. 5-22.

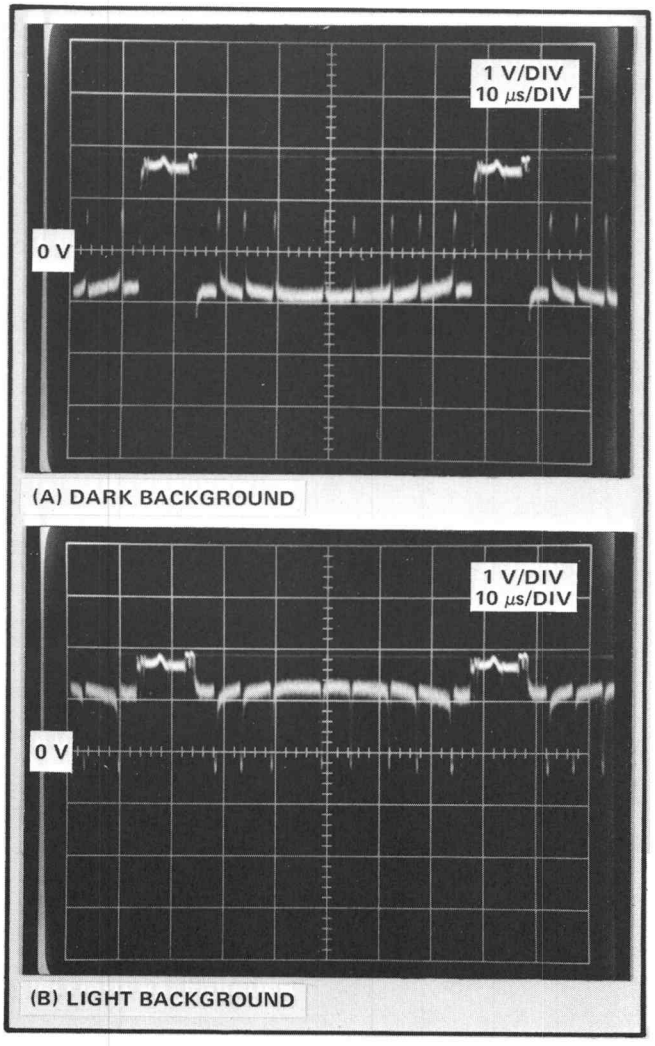


Fig. 5-22. Video amplitude and Background Offset level (TP765) after proper adjustment.

37. Check/Adjust Horizontal Shading

a. Adjust R875 (Horizontal Shading Amplitude) and R885 (Horizontal Shading Centering) to obtain the straightest possible video background. The location of these controls is shown in Fig. 5-23.

b. Check for straightness of the portion of the display representing the background level in both DARK and LIGHT. The waveforms of Fig. 5-25A and 25B show correct adjustment, and Fig. 5-25C shows the effect of an exaggerated misadjustment of the horizontal shading amplitude adjustment.

38. Check/Adjust Cancel Balance

a. Adjust R798 (Cancel Balance in Fig. 5-23) to null (cleanest baseline) the video during horizontal blanking.

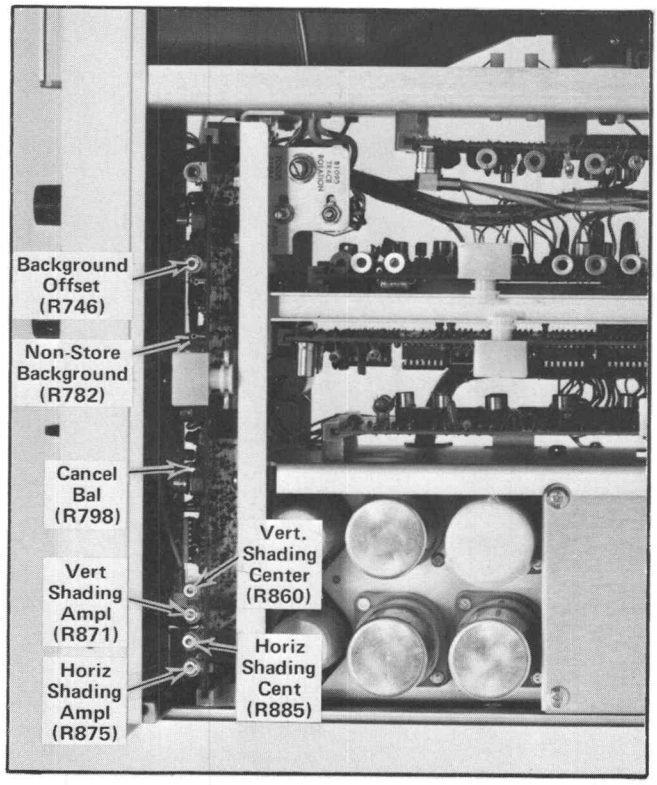


Fig. 5-23. Location of Read Amplifier Adjustments.

b. Fig. 5-26 shows the Cancel Balance correctly set.

39. Check/Adjust Vertical Shading

a. Switch oscilloscope to 5 ms/div.

b. Video should appear as in Fig. 5-27. Adjustments R871 (Vertical Shading Amplitude) and R860 (Vertical

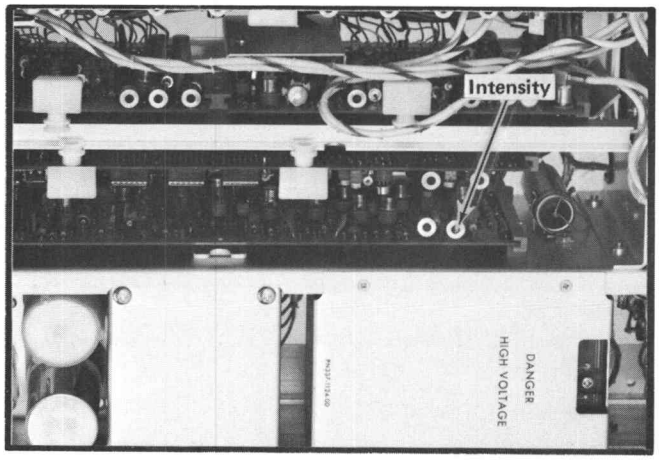


Fig. 5-24. Adjustments used when setting video amplitude.

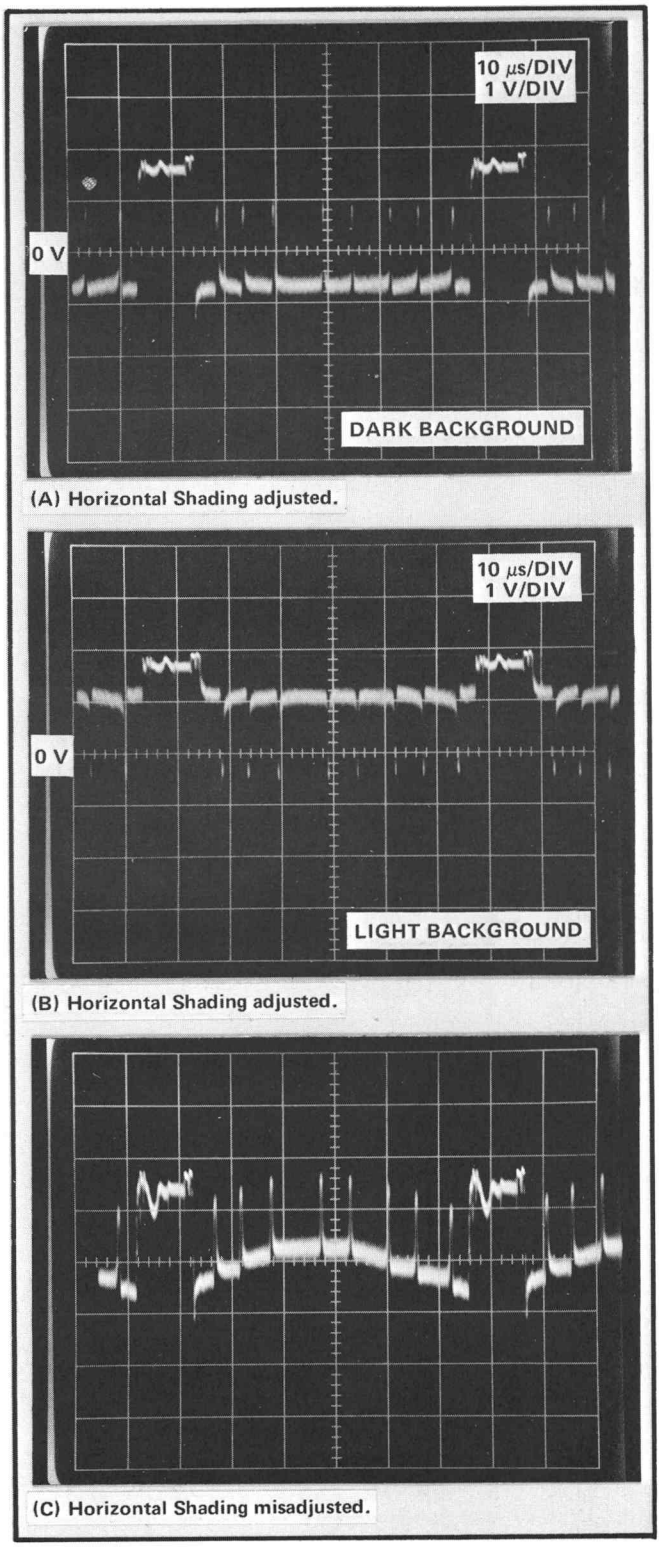


Fig. 5-25. Effect of Horizontal Shading adjustments on waveforms at TP765.

Shading Centering) are adjusted to obtain straightest video background. Start with Shading Amplitude fully CCW. Very little or no correction is normally needed.

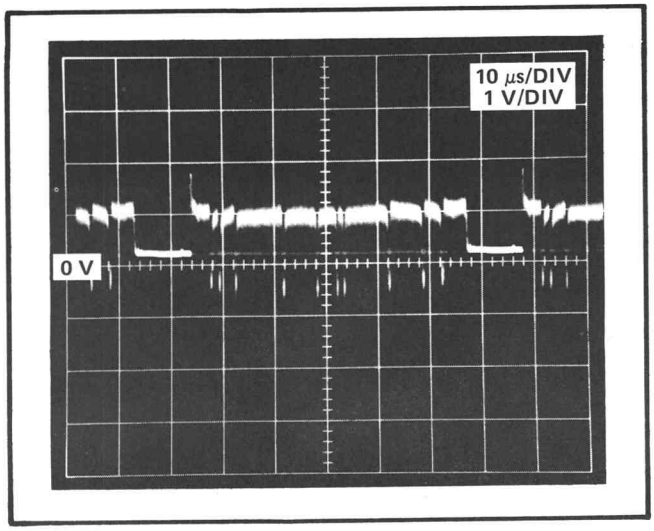


Fig. 5-26. Waveform at TP765 with Cancel Bal (R798) properly adjusted.

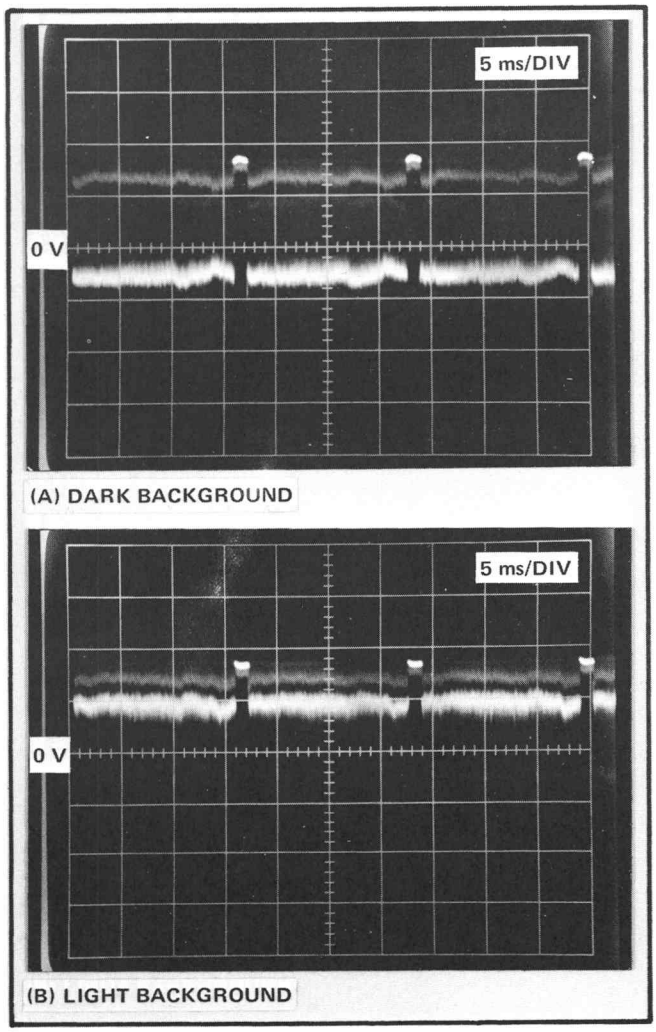


Fig. 5-27. Waveforms at TP765 with Vertical Shading adjustments properly set.

40. Check/Adjust Video Output

a. Connect a 75 Ω load to J1280. Optional loads are: a 75 Ω coaxial termination, a video cable to the 75 Ω input on a TV picture monitor, or a 75 Ω resistor.

b. Set S1280 to the Internal Video Only position.

c. Connect a 10X probe to TP838.

d. Switch oscilloscope to 10 μs/div. Fig. 5-28 illustrates the video signal at this point. R746 (Background Offset) can be trimmed up to optimize video clipping. Improper adjustment will cause severe video clipping as illustrated as shown in Fig. 5-28A. Fig. 5-28A is a double-exposure showing the effect of both too low and too high a setting of the Background Offset control with DARK background selected. Fig. 5-28B and 5-28C show waveforms resulting with correct Background Offset adjustment.

e. Adjust the TV picture monitor contrast and brightness to optimize the display for LIGHT and DARK BACKGROUND video.

f. Scan through previous steps for Read Amplifier adjustments and make minor touch up adjustments if necessary.

41. Adjust Nonstore Background

a. Switch to NON-STORE.

b. With the Type 4501 in WRITE AND READ mode, move the writing spot around the screen.

c. Adjust R782 for maximum video consistent with a clean picture background.

d. Repeat step 11b. to optimize non-store readout performance.

MODULATOR

42. Adjust Modulation Level

a. Disconnect the coaxial cable from the composite video output connector and connect it to the RF output connector. Connect the 75 ohm end line terminator to the composite video output. Set the test oscilloscope to 20 mV and 2 ms.

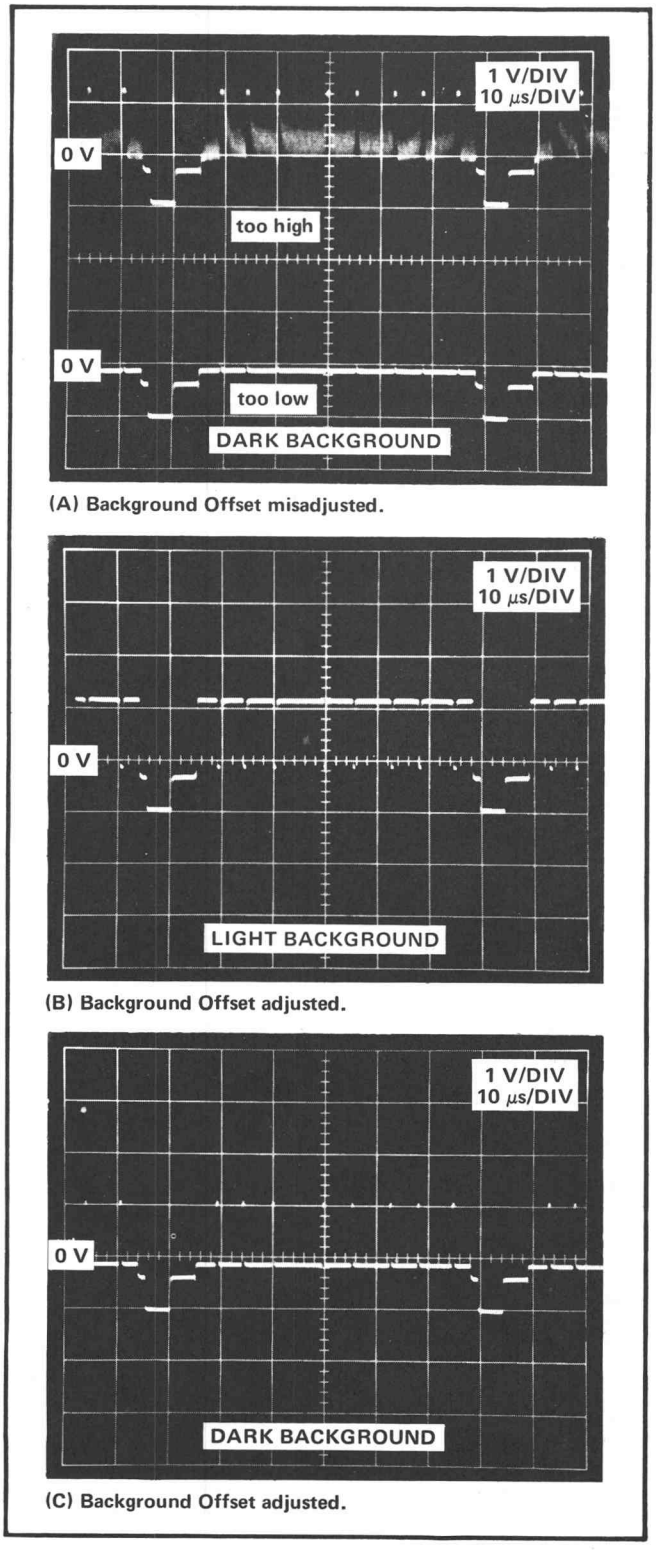


Fig. 5-28. Effect of Background Offset adjustment (R746) on waveforms at TP838.

b. Adjust the Modulation Level, R915, (see Fig. 5-29) for maximum video on the carrier (Maximum modulation, see Fig. 5-30).

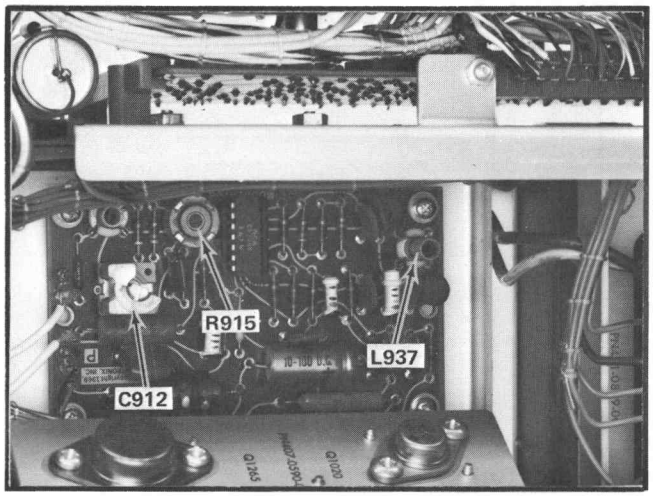


Fig. 5-29. Location of Modulator adjustments.

c. ADJUST—C912, (see Fig. 5-29) for maximum output as displayed on the test oscilloscope.

CAUTION

The RF output is approximately 15 mW. Depending on the receiver, an RF attenuator may be required.

d. OPTIONAL—To peak U.S. Channel 3 or to change to U.S. Channel 2 or 4: Connect a 75 Ω coaxial cable from the RF output on the Type 4501 to a television receiver and set the television receiver to the desired channel, then adjust L937, (see Fig. 5-29) for optimum video on the television set.

This completes the calibration procedure for the Type 4501.

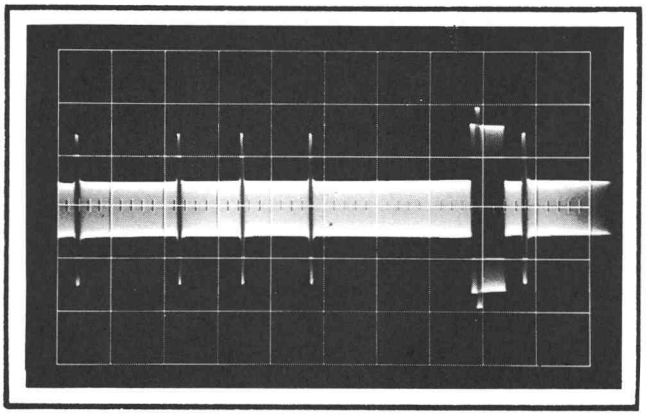


Fig. 5-30. Modulation level adjusted for maximum modulation.

The following steps are optional and may be performed if the test equipment is available. Step 1, Adjust RF Output Frequency, may be desirable if more than one television receiver is being driven from the Type 4501.

1. Adjust RF Output Frequency

a. Connect a BNC T connector to the 100 MHz input connector on a Systron-Donner, Model 7015 counter. Connect a coaxial cable from the T connector to the RF output connector on a Type 4501. Connect a 75 Ω termination to the test oscilloscope channel 1 input. Connect a coaxial cable from the T connector to the test oscilloscope channel 1 input.

b. While monitoring the test oscilloscope, adjust the RF modulation level (R915) for minimum modulation and adjust C912 for maximum carrier amplitude.

c. Set the Systron-Donner Counter as follows:

Set the Rate switch to 100 Hz. Set the attenuator to 1. Set the AC-DC switch to AC and the Range switch to 100 MHz. Set the Re-cycle Rate for a useful display.

d. ADJUST—L937 for 61.25 MHz ±200 kHz. While adjusting L937, maintain maximum carrier amplitude on the test oscilloscope by slightly adjusting C912.

e. Adjust R915 RF modulation level for maximum modulation.

2. Check X-Y Phase Difference ⩽ 10° at MHz

NOTE

Prior to performing this check, insure that the Type 4501 X and Y Gain is correctly set.

a. Connect a 5 ns cable to the output connector on the Type 191 and set the Type 191 frequency output to 10 MHz.

b. Connect a 50 Ω BNC to GR terminator to the 5 ns cable and connect the BNC dual input connector to the 50 Ω terminator. Connect one end of the BNC dual input connector to the +Y input. Adjust the Type 191 Amplitude for 6 centimeters of display on the Type 4501.

c. Connect the other end of the BNC dual input connector to the +X input.

d. CHECK—≤ 1 cm separation between traces.

3. Check Stored Resolution and Writing Time

a. Test equipment required is 067-0561-00, Calibration Fixture, Test Display Generator.

b. Connect a coaxial cable from the X, Y and Z outputs of the calibration fixture to the +X, +Y and +Z inputs of the Type 4501 respectively.

c. Set the calibration fixture controls as follows:

Mode	Ready/Raster
Density	X-Y
Dots	125:100
Time/Dot	5 μs
Amplitude	1
Time/Line	2 ms

d. Set the Type 4501 controls as follows:

MODE	WRITE ONLY
STORE/NON-STORE	STORE

e. It may be necessary to reduce the Type 4501 vertical and horizontal gain to obtain a display 7.5 centimeters vertically and 10 centimeters horizontally.

f. Set the calibration fixture Mode switch to Cont and center the display with the Type 4501 positioning controls.

g. Set the calibration fixture Mode switch to Ready and erase the display.

h. Depress the Mode switch to Single and note the display.

NOTE

Intensity setting is critical for the following check.

i. CHECK—The stored dots over entire graticule area for any indication of bridging (dots touching) or dropouts (dots missing). None allowed.

j. Erase the Type 4501 and disconnect the calibration fixture.

NOTES

SECTION 6
RACKMOUNTING

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section of the manual contains information for field converting the rackmount model of the Scan Converter into a bench model and vice versa. There are also rackmounting installation instructions using the 1 3/4-inch wide slide-out tracks in a non-tilt installation.

RACKMOUNT-TO-BENCH CONVERSION

Converting the Scan Converter From a Rackmount Model (Type R4501) to a Bench Model (Type 4501).

Remove these parts (see Fig. 6-1A):

1. Adhesive-backed blue trim strip from top rear-portion of the instrument.

2. Remove the chassis section of the slide-out tracks (both sides).

3. Remove two screws from each angle bracket (both sides of the instrument) to remove the handle and angle bracket assembly as a unit.

Add these parts (see Fig. 6-1B):

1. Mount the front handle on the instrument by first laying the front plastic plates in line with the holes on the top edge of the front casting. Then, align the handle over the plates and fasten these parts to the instrument using the 10-32 X 0.40-inch screws.

2. Mount the rear handle on the instrument by first laying the rear plastic plates in line with holes on the top of the rear casting. Then, align the handle over the plates and fasten these parts to the instrument using the 10-32 X 0.40-inch screws.

3. Lay the plastic end cover over the handle screws. Apply finger pressure to snap the cover into place. Repeat this procedure to install all four covers.

4. Peel the paper backing from the adhesive side of the blue trim strips. Press the blue strips into place at the left and right sides of the instrument where the rackmount angle brackets have been removed.

5. Remove the bottom from the instrument and install the four feet. Each foot can be easily installed by holding the screw in the hole and threading the foot onto the screw. Repeat this procedure for all four feet.

6. Install the bottom cover.

BENCH-TO-RACKMOUNT CONVERSION

Converting a Bench Model (Type 4501) to a Rackmount Model (Type R4501):

Remove the parts that were added in Fig. 6-1B and described in the previous procedure. Add the parts that were removed in the previous procedure and illustrated in Fig. 6-1A. To install the blue trim strip, remove the paper backing and press the trim strip into place where the rear handle was removed.

NOTE

Before mounting the rackmount handles on the instrument, the parts for the handle and angle bracket assembly may be pre-assembled as shown in the Fig. 6-2 illustration. Use appropriate size retaining ring pliers to install the retaining ring on the thumb screw shaft.

When mounting the chassis sections of the slide-out tracks, the pivot screw and tilt stop hardware supplied by the slide-out track manufacturer are not used. Instead, use the 8-32 X 5/16-inch screws (212-0068-00) to mount the chassis sections to the sides of the instrument for a non-tilt installation.

RACKMOUNTING INSTRUCTIONS

Mounting Methods (Figs. 6-3, 6-4 and 6-7

This instrument will fit most commercial consoles and most 19-inch wide racks whose front and rear rail holes conform to EIA/RETMA/Western Electric or Universal hole spacing (see Fig. 6-7A).

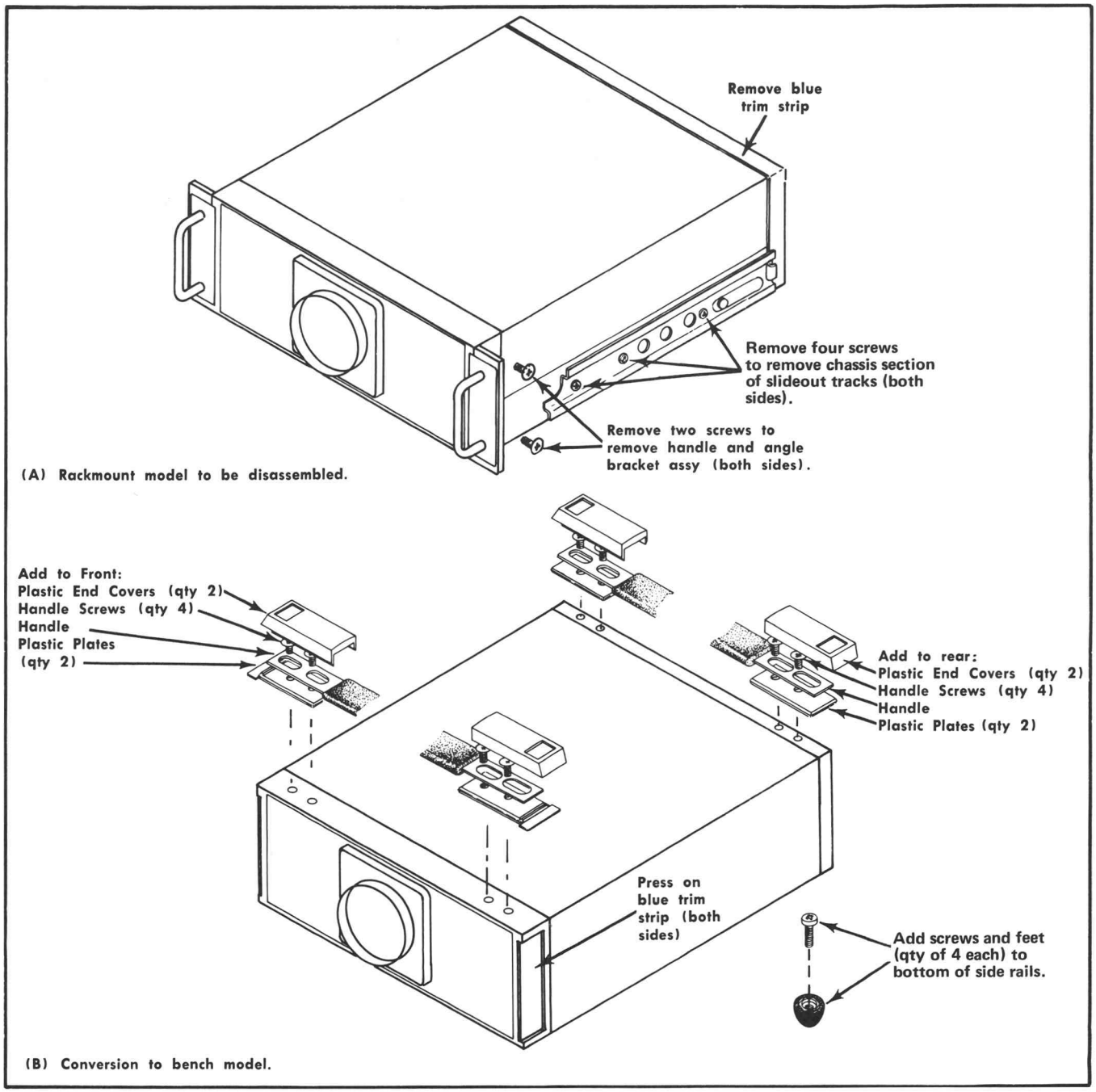


Fig. 6-1. Converting a rackmount Scan Converter into a bench model.

Fig. 6-3 shows the instrument installed in a cabinet type rack with 1 3/4-inch wide slide-out tracks for a non-tilt installation. The instrument is secured into the rack by means of two knurled thumb screws. When the thumb screws on the front panel are loosened to release the instrument, the instrument can be pulled out of the rack like a drawer to its fully extended position (see Fig. 6-4). This position permits many routine maintenance functions to be performed without completely removing the instrument from the rack.

The slide-out tracks easily mount to the cabinet rack front and rear vertical mounting rails if the inside distance between the front and rear rails is within 12 5/16 inches to 26 3/8 inches. Some means of support (for example, make extensions for the rear mounting brackets) is needed to support the rear ends of the slide-out tracks if the tracks are going to be installed in a cabinet rack whose inside dimensions between front and rear rails is not the proper distance (12 5/16 inches to 26 3/8 inches).

Instrument Dimension

The last pullout page in this section shows dimensional drawings exclusive of the power cord and cables.

Rack Dimensions

Width—A standard 19-inch rack may be used. The dimension or opening between the front rails must be at least 17 5/8 inches (see Fig. 6-4) for a cabinet rack in which the front lip of the stationary section is mounted behind an untapped front rail as shown in Fig. 6-7B. If the front rails are tapped and the stationary section is mounted in front of the front rails as shown in Fig. 6-7C, the dimension between the front rails should be at least 17 3/4 inches. These dimensions allow room on each side of the instrument for the slide-out tracks to operate so the instrument can move freely in and out of the rack.

Depth—For proper circulation of cooling air, allow at least 2 inches clearance behind the rear of the instrument and any enclosure on the rack (see dimensional drawing). If it is sometimes necessary or desirable to operate the Type R4501 in the fully extended position, use cables that are long enough to reach from the signal source to the instrument.

Rackmounting in a Cabinet Rack

General Information. The slide-out tracks for the instrument consist of two assemblies, one for the left side of the instrument and one for the right side. Each assembly consists of three sections as illustrated in Fig. 6-5. The stationary section attaches to the front and rear rails of the rack with inside dimensions as indicated in Fig. 6-4; the chassis section attaches to the instrument and is installed at the factory; the intermediate section fits between the other two sections to allow the instrument to fully extend out of the rack.

The small hardware components included with the slide-out track assemblies are shown in Fig. 6-6. The hardware shown in Fig. 6-6 is used to mount the slide-out tracks to the rack rails having this compatibility.

(a) Front and rear rail holes must be large enough to allow inserting a 10-32 screw through the rail mounting holes if the rails are untapped (see Fig. 6-7B).

(b) Or, front and rear rail holes must be tapped to accept a 10-32 screw if Fig. 6-7C mounting method is used. Note in Fig. 6-7C right hand illustration that a #10 washer (not supplied) may be added to provide increased bearing surface for the slide-out track stationary section front flange.

(c) Front and rear rail holes must be located on either EIA/RETMA/Western Electric or Universal spacing; that is, the sequence for the hole spacing is: 1/2 inch, 1 1/4 inch, 1/2 inch, 1 1/4 inch, or 5/8 inch, 1/2 inch, 5/8 inch, 1/2 inch.

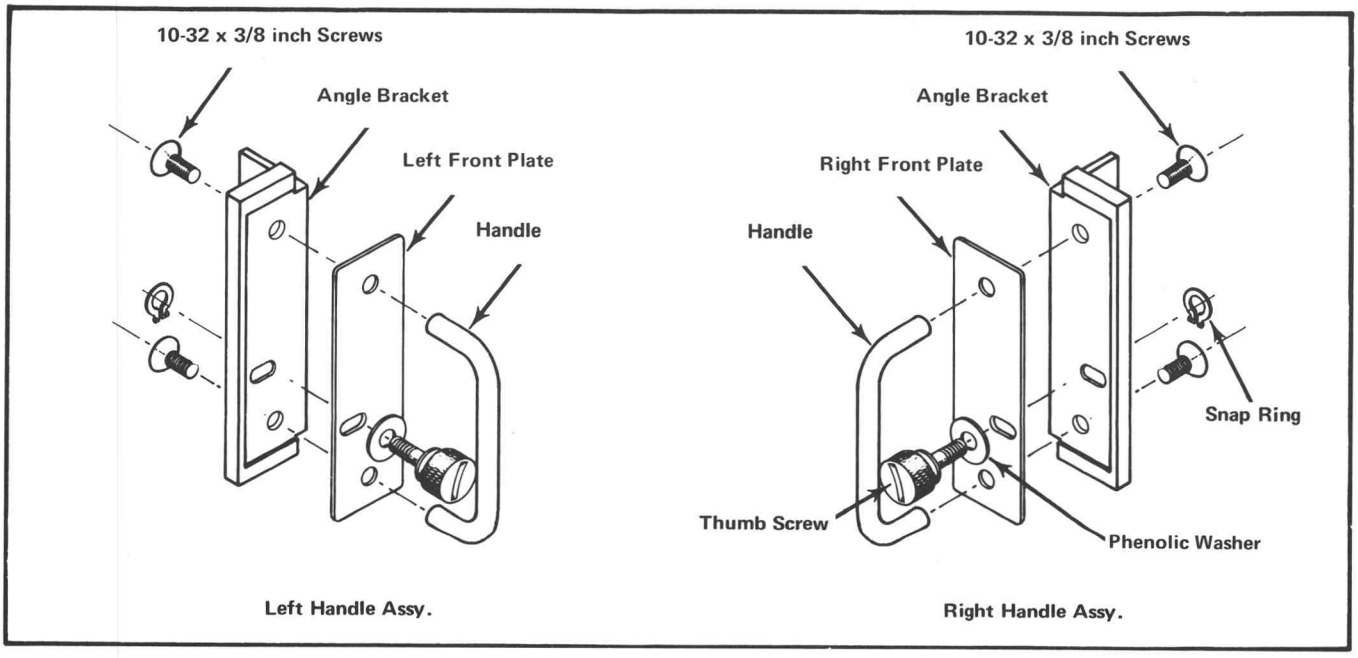


Fig. 6-2. Assembling the handles for the rackmount model.

Because of the above compatibility, there will be some small parts left over.

The stationary and intermediate sections for both sides of the rack are shipped as a matched set and should not be separated. The matched sets for both sides including hardware are marked 351-0241-00 on the package. To identify the assemblies, note that the automatic latch and intermediate section stop are located near the top of the matched set.

Mounting Procedure. Use the following procedure to mount both sets. See Fig. 6-7 for installation details.

1. To mount the instrument directly above or below another instrument in the cabinet rack, select the appropriate holes in the front rack rails for the stationary sections using Fig. 6-7A as a guide.

2. Mount the stationary slide-out track sections to the front rack rails using either of these methods:

(a) If the front flanges of the stationary sections are to be mounted behind the front rails (rails are countersunk or not tapped), mount the stationary sections as shown in Fig. 6-7B right hand illustration.

(b) If the front flanges of the stationary sections are to be mounted in front of the front rails (rails are tapped for 10-32 screws), mount the stationary sections as shown in Fig. 6-7C right hand illustration. To provide increased bearing surface for the screw head to securely fasten the front flange to the rail, a flat washer (not supplied) may be added under the screw head. However, consider that using this mounting method, the front panel will not fit flush against the front rail because of the stationary section and washer thickness. If a flush fit is preferred, method 2 (a) should be used.

3. Mount the stationary slide-out track sections to the rear rack rails using either of these methods:

(a) If the rear rack rail holes are not tapped to accept 10-32 machine screws, mount the left stationary section with hardware provided as shown in the left-hand or center illustration of Fig. 6-7B. Note that the rear mounting bracket can be installed either way so the slide-out tracks will fit a deep or shallow cabinet rack. Use Fig. 6-7B as a guide for mounting the right stationary section. Make sure the stationary sections are horizontally aligned so they are level and parallel with each other.

(b) If the rear rack rail holes are tapped to accept 10-32 machine screws, mount the left stationary section with hardware provided as shown in the left-hand or center illustration of Fig. 6-7C. Note that the rear mounting bracket can be installed either way so the slide-out tracks will fit a deep or shallow cabinet rack. Use Fig. 6-7C as a guide for mounting the right stationary section. Make sure the stationary sections are horizontally aligned so they are level and parallel with each other.

Adjustments

To adjust the slide-out tracks for smooth operation, proceed as follows:

1. Insert the instrument into the rack as shown in Fig. 6-8.

2. Adjust the slide-out tracks for proper spacing as shown in Fig. 6-9.

Maintenance

The slide-out tracks require no lubrication. The special dark gray finish on the sliding parts is a permanent lubrication.

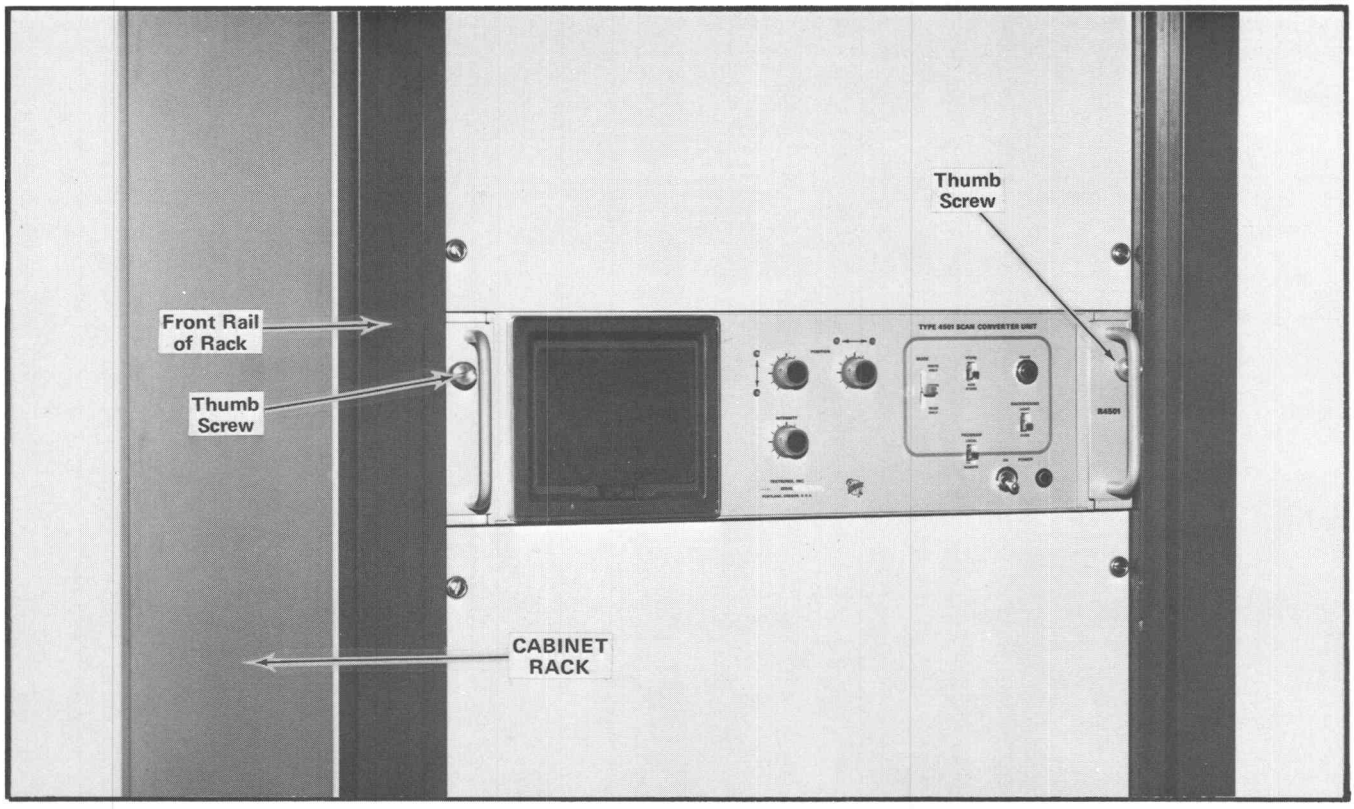


Fig. 6-3. The Type R4501 installed in a cabinet type rack.

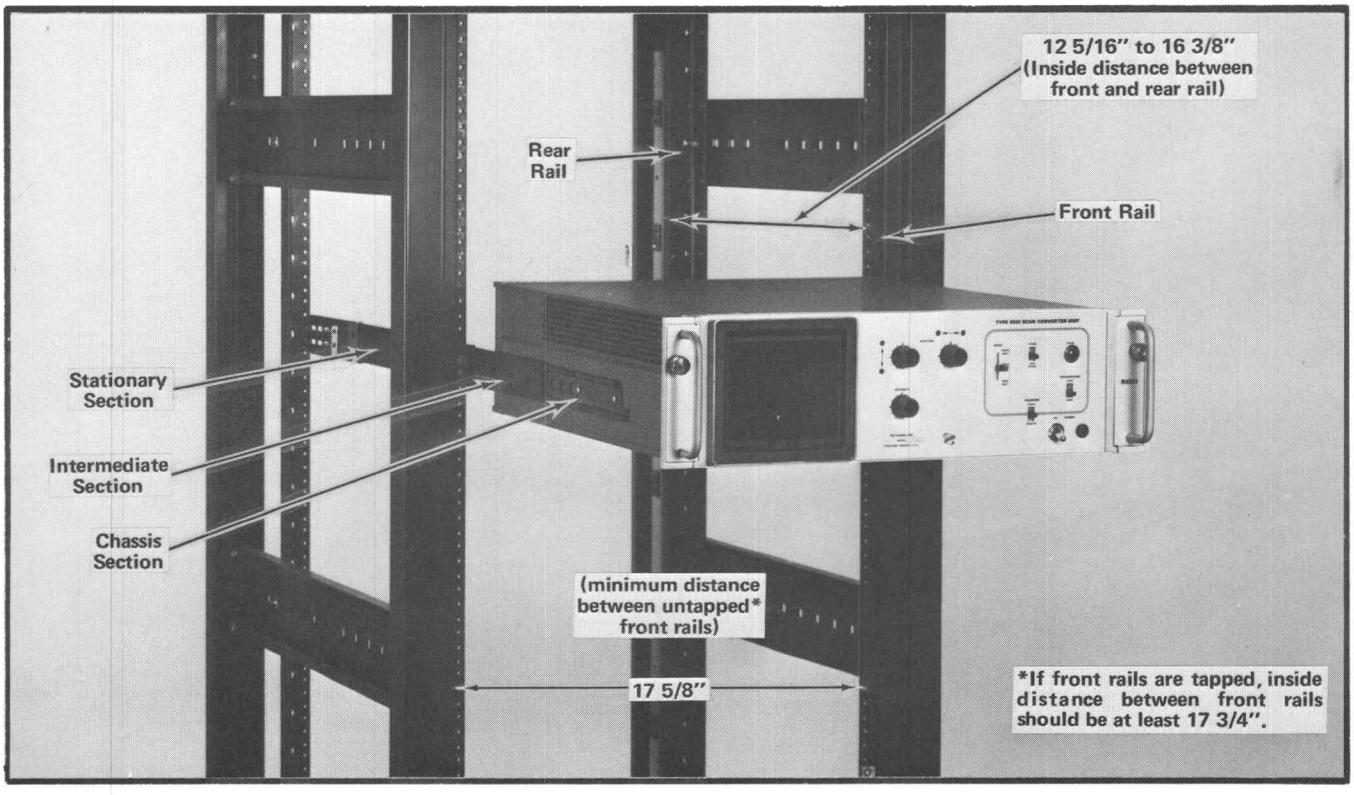


Fig. 6-4. The Type R4501 shown in the fully extended position. The cabinet sides have been removed from the rack to show mounting details.

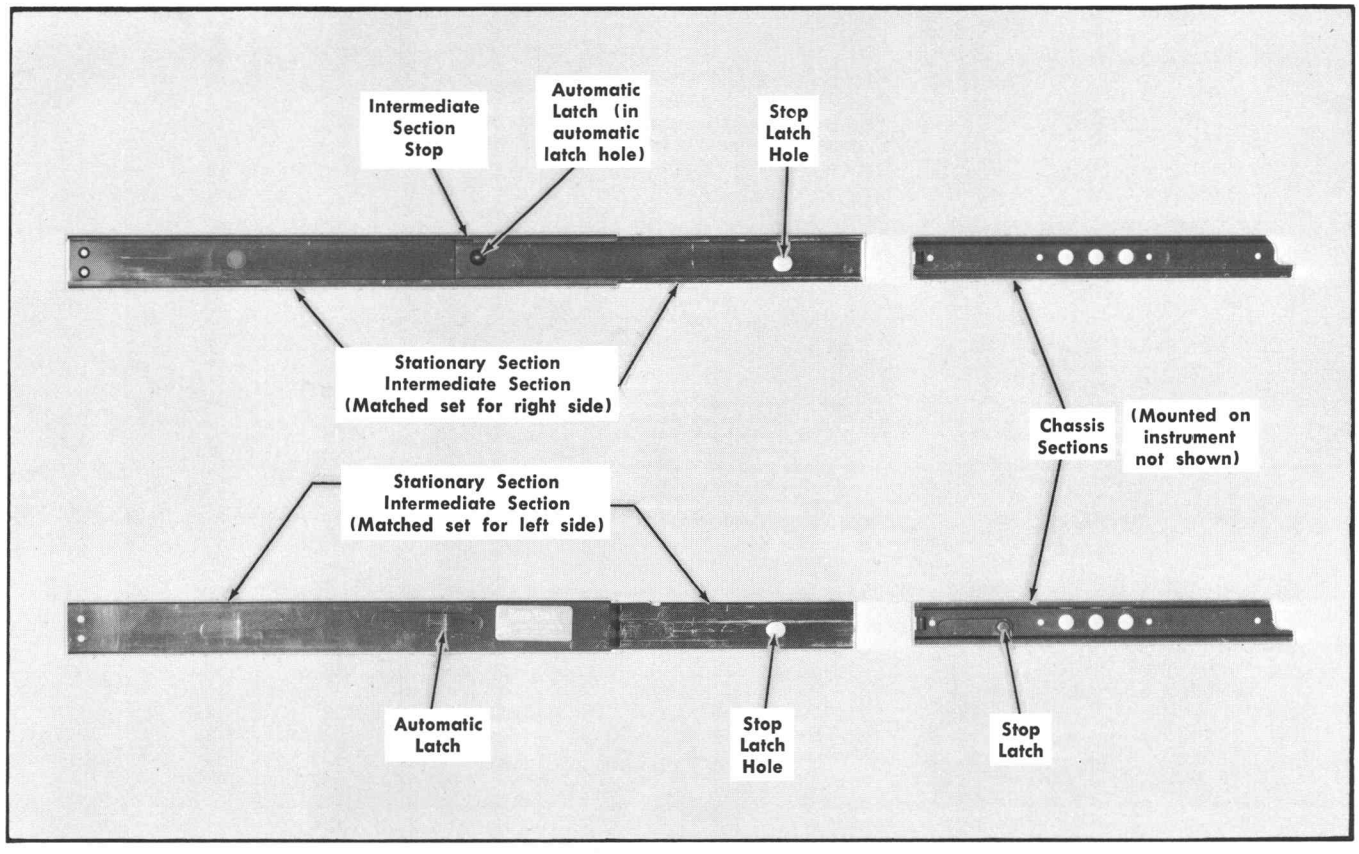


Fig. 6-5. Illustrations showing the 1¾-inch wide slide-out track assemblies.

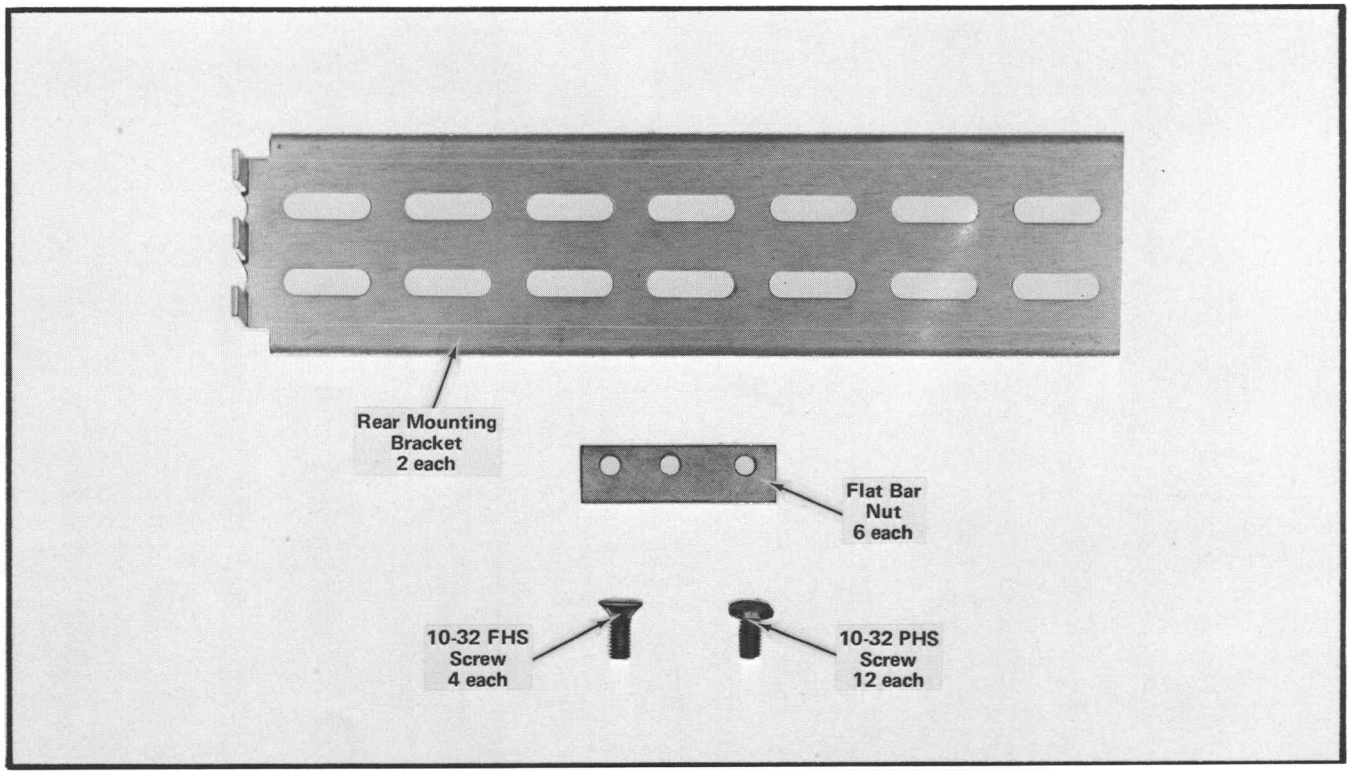


Fig. 6-6. Small hardware components for mounting the stationary sections to the rack rails.

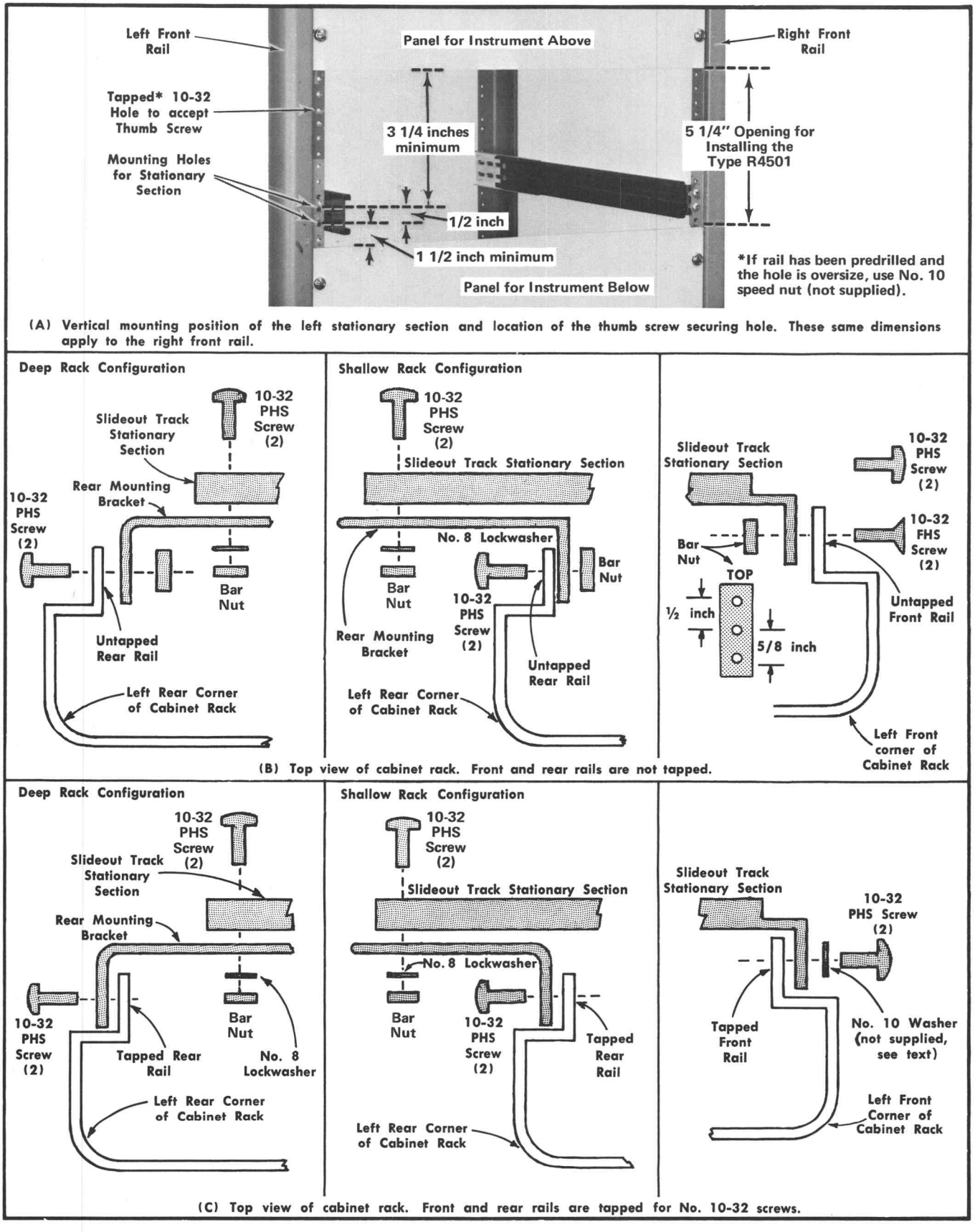


Fig. 6-7. Mounting the left stationary section (with its matched intermediate section, not shown in illustrations B and C) to the rack rails.

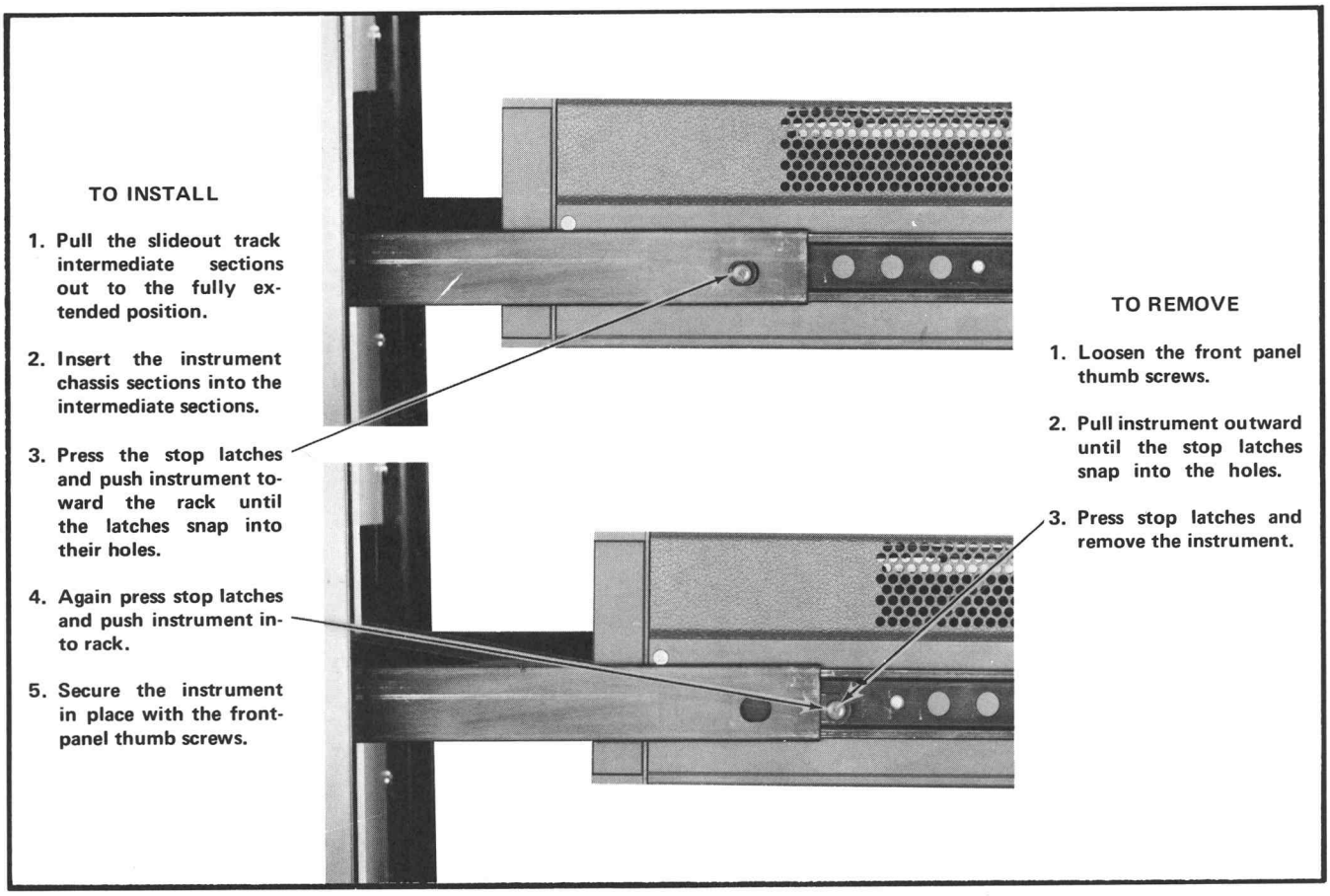


Fig. 6-8. Installing and removing the instrument.

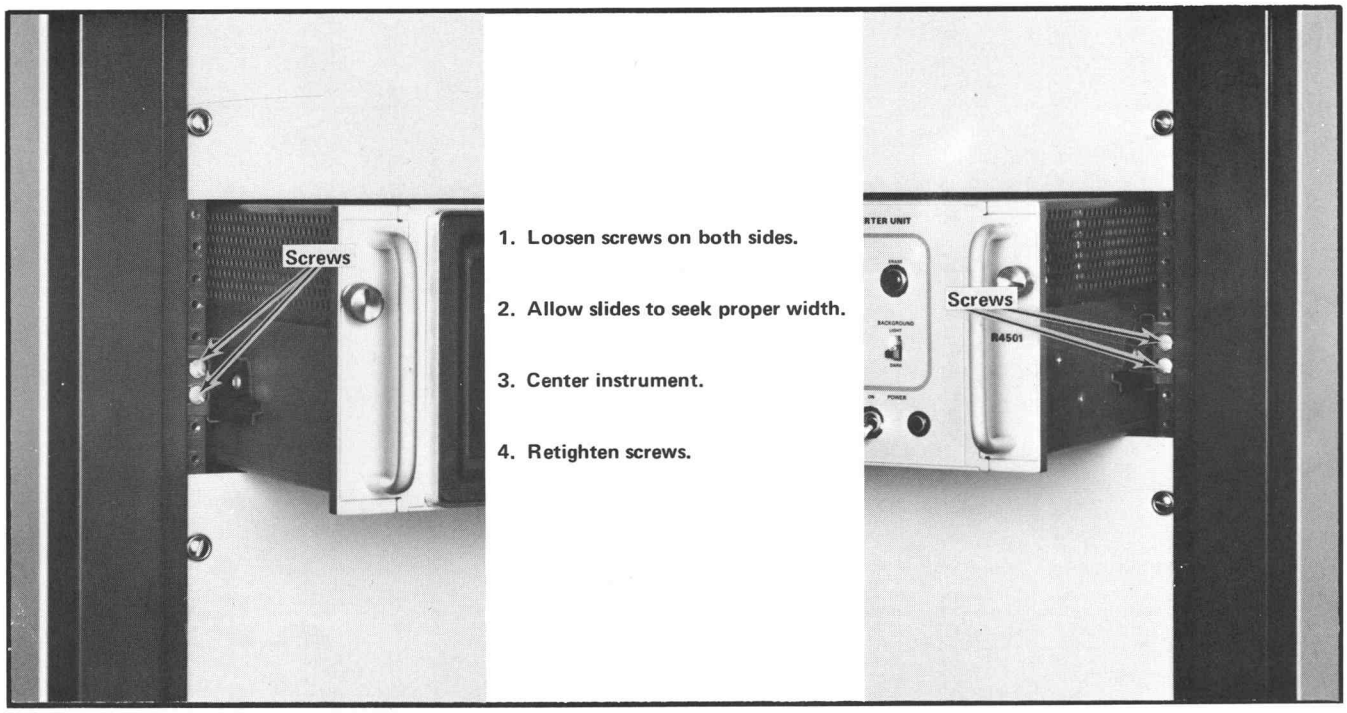


Fig. 6-9. Adjusting the slide-out tracks for smooth sliding action.

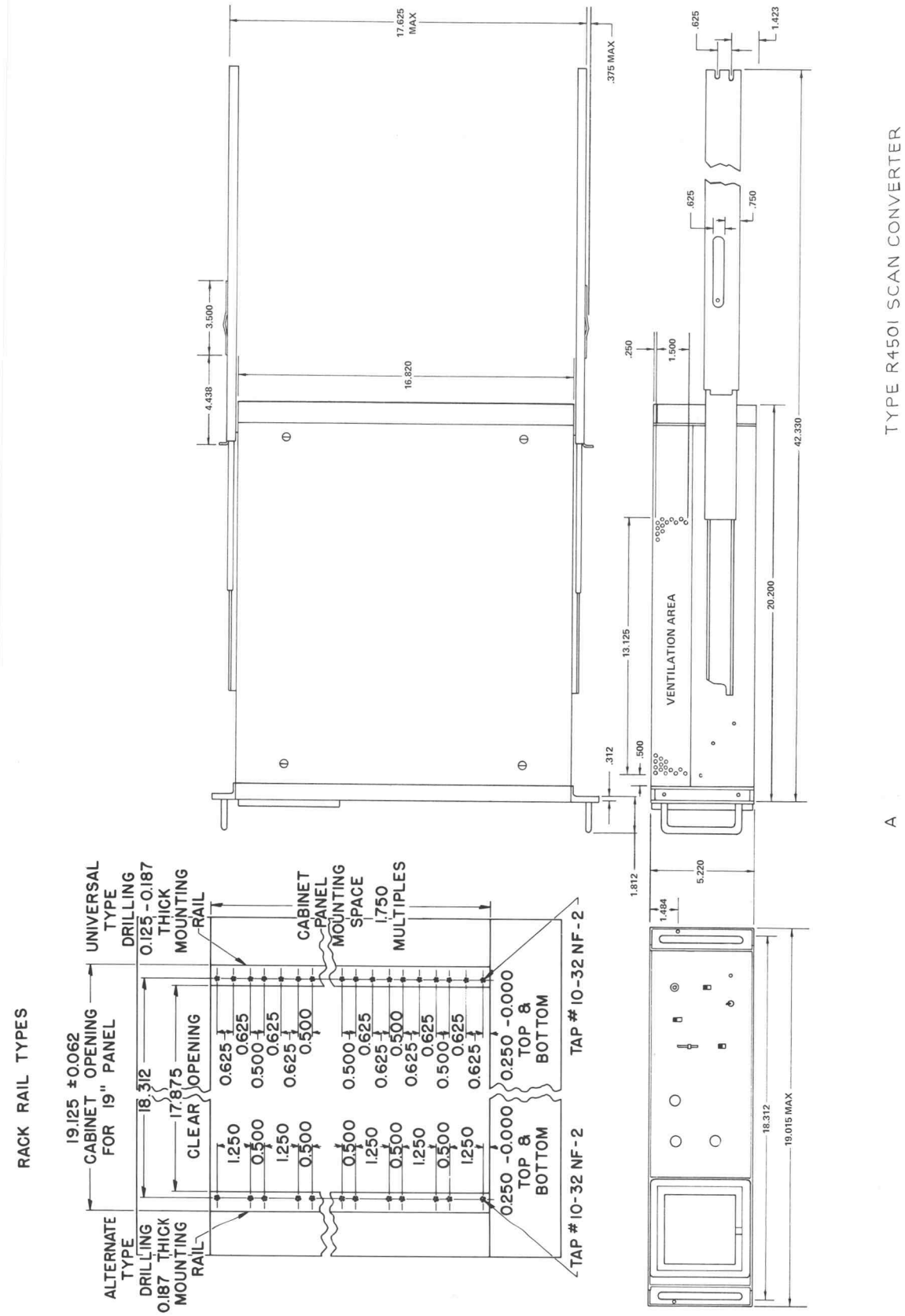


Fig. 6-10. Type R4501 Dimension Drawing.

NOTES

PARTS LIST ABBREVIATIONS

BHB	binding head brass
BHS	binding head steel
cap.	capacitor
cer	ceramic
comp	composition
conn	connector
CRT	cathode-ray tube
csk	countersunk
DE	double end
dia	diameter
div	division
elect.	electrolytic
EMC	electrolytic, metal cased
EMT	electrolytic, metal tubular
ext	external
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
h	height or high
hex.	hexagonal
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
ID	inside diameter
inc	incandescent
int	internal
lg	length or long
met.	metal
mtg hdw	mounting hardware
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
P/O	part of
PHB	pan head brass
PHS	pan head steel
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
RHB	round head brass
RHS	round head steel
SE	single end
SN or S/N	serial number
S or SW	switch
TC	temperature compensated
THB	truss head brass
thk	thick
THS	truss head steel
tub.	tubular
var	variable
w	wide or width
WW	wire-wound

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.

INDEX OF ELECTRICAL PARTS LIST

SECTION 7
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				CHASSIS		
				Fan		
B1102	119-0215-00			Fan, axial	115 V, 13 W	
				Capacitors		
Tolerance ±20% unless otherwise indicated.						
C490	281-0604-00			2.2 pF	(nominal value) Selected	
C491	283-0008-00			0.1 μF	Cer 500 V	
C492	283-0008-00			0.1 μF	Cer 500 V	
C591	283-0008-00			0.1 μF	Cer 500 V	
C592	283-0008-00			0.1 μF	Cer 500 V	
C684	285-0537-00			0.5 μF	MPT 400 V	
C685	283-0008-00			0.1 μF	Cer 500 V	
C1108	290-0260-00			50 μF	Elect. 200 V	
C1142A	290-0419-00			300 μF	Elect. 300 V	
C1142B				50 μF	Elect. 300 V	
C1142C				5 μF	Elect. 300 V	
C1142D				20 μF	Elect. 100 V	
C1165A	290-0418-00			300 μF	Elect. 100 V	
C1165B				3000 μF	Elect. 25 V	
C1165C				200 μF	Elect. 25 V	
C1165D				1000 μF	Elect. 6 V	
C1205	290-0321-00			11,000 μF	Elect. 15 V	+100%—10%
C1225	290-0333-00			300 μF	Elect. 25 V	+75%—10%
C1228	290-0320-00			4500 μF	Elect. 40 V	+100%—10%
C1246	290-0266-00			290 μF	Elect. 15 V	
C1264	290-0271-00			9 μF	Elect. 125 V	+20%—15%
C1265	290-0018-00			150 μF	Elect. 150 V	
C1268	290-0277-00			2 x 140 μF	Elect. 100 V	
				Semiconductor Device, Diodes		
CR1030	152-0408-00			Silicon	High voltage, 10 kV	
CR1070	152-0408-00			Silicon	High voltage, 10 kV	
				Bulbs		
DS490	150-0055-00			Neon 5AB-B		
DS495	150-0055-00			Neon 5AB-B		
DS590	150-0055-00			Neon 5AB-B		
DS595	150-0055-00			Neon 5AB-B		
DS1205	150-0065-00			Incandescent	10 V, 40 mA green lens	

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
				Fuses	
F1101	159-0023-00			2 A 3AG Slo-blo	
F1102	159-0019-00			1 A 3AG Slo-blo	
				Connectors	
J1	131-0274-00			BNC	
J2	131-0274-00			BNC	
J66	131-0274-00			BNC	
J131	131-0274-00			BNC	
J132	131-0274-00			BNC	
J158	131-0274-00			BNC	
J915	131-0126-00			BNC, single contact	
J1100	131-0292-01			56 pin	
J1101	131-0572-00			Receptacle, electrical	
J1280	131-0126-00			BNC, single contact	
J1285	131-0126-00			BNC, single contact	
J1290	131-0292-01			56 pin	
J1292	131-0327-00			30 pin	
J1294	131-0327-00			30 pin	
J1296	131-0327-00			30 pin	
J1298	131-0292-01			56 pin	
J1300	131-0126-00			BNC, single contact	
J1302	131-0569-00			Receptacle, electrical	
J1304	131-0408-00			Receptacle, electrical, 37 pin	
J1305	131-0126-00			BNC, single contact	
J1310	131-0126-00			BNC, single contact	
J1315	131-0126-00			BNC, single contact	
J1320	131-0126-00			BNC, single contact	
J1325	131-0126-00			BNC, single contact	
				Inductors	
L1	*108-0496-00			0.4 μH	
L131	*108-0496-00			0.4 μH	
L490	*114-0306-00			68-123 μH, Var	Core 276-0511-00
L492	*114-0305-00			3.5-6 μH, Var	Core 276-0506-00
L495	*114-0306-00			68-123 μH, Var	Core 276-0511-00
L497	*114-0305-00			3.5-6 μH, Var	Core 276-0506-00
L510	276-0519-00	XB130000		Core, Powdered Iron	
L590	*114-0306-00			68-123 μH, Var	Core 276-0511-00
L592	*114-0305-00			3.5-6 μH, Var	Core 276-0506-00
L595	*114-0306-00			68-123 μH, Var	Core 276-0511-00
L597	*114-0305-00			3.5-6 μH, Var	Core 276-0506-00
L1090	*108-0495-00			Trace Rotator	

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
				Transistors
Q490	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q495	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q590	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q595	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q1020	151-0201-00			Silicon NPN TO-66 2N3739
Q1145	*151-0256-00			Silicon NPN TO-3 Tek Spec
Q1165	*151-0140-00			Silicon NPN TO-3 Selected from 2N3055
Q1185	*151-0140-00			Silicon NPN TO-3 Selected from 2N3055
Q1205	*151-0148-00			Silicon NPN TO-66 Selected from RCA 40250
Q1225	*151-0140-00			Silicon NPN TO-3 Selected from 2N3055
Q1245	*151-0148-00			Silicon NPN TO-66 Selected from RCA 40250
Q1265	*151-0140-00			Silicon NPN TO-3 Selected from 2N3055
				Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R253	311-0011-00	5 kΩ, Var			
R441	311-0011-00	5 kΩ, Var			
R490	315-0224-00	220 kΩ	1/4 W		5%
R491	315-0304-00	300 kΩ	1/4 W		5%
R492	*310-0674-00	3 kΩ	8 W	WW	1%
R495	315-0224-00	220 kΩ	1/4 W		5%
R497	*310-0674-00	3 kΩ	8 W	WW	1%
R541	311-0011-00	5 kΩ, Var			
R590	315-0224-00	220 kΩ	1/4 W		5%
R591	315-0304-00	300 kΩ	1/4 W		5%
R592	*310-0674-00	3 kΩ	8 W	WW	1%
R595	315-0224-00	220 kΩ	1/4 W		5%
R597	*310-0674-00	3 kΩ	8 W	WW	1%
R1084	311-0121-01	5 MΩ, Var			
R1090	311-0576-00	2 x 1 kΩ, Var			
R1092	311-0641-00	200 kΩ, Var			
R1108	302-0154-00	150 kΩ	1/2 W		
R1147	304-0104-00	100 kΩ	1 W		
R1165	302-0273-00	27 kΩ	1/2 W		
R1168	304-0562-00	5.6 kΩ	1 W		
R1187	302-0332-00	3.3 kΩ	1/2 W		
R1188	302-0101-00	100 Ω	1/2 W		
R1205	302-0391-00	390 Ω	1/2 W		
R1228	302-0332-00	3.3 kΩ	1/2 W		
R1268	302-0273-00	27 kΩ	1/2 W		

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Description		
			Resistors (cont)			
R1280	321-0039-00		24.9 Ω	1/8 W	Prec	1%
R1281	321-0039-00		24.9 Ω	1/8 W	Prec	1%
R1284	321-0068-00		49.9 Ω	1/8 W	Prec	1%
R1285	321-0039-00		24.9 Ω	1/8 W	Prec	1%
			Switches			
	Wired or Unwired					
S601	260-0574-00		Pushbutton	ERASE		
S648	260-0449-00		Slide	STORE NON-STORE		
S1101	260-0276-00		Toggle			
S1103[1]						
S1104[1]						
S1275	260-0449-00		Slide	BACKGROUND		
S1280	260-0447-00		Slide			
S1290	260-0798-00		Lever	MODE		
S1320	260-0449-00		Slide	PROGRAM		
			Thermal Cut-Out			
S1102	260-0413-00		175° F ± 5° F			
			Transformers			
T1020	*120-0623-00		HV Power			
T1101	*120-0622-00		LV Power			
			Electron Tube			
V690	*154-0616-00		CRT Standard Phosphor			

[1]See Mechanical Parts List. Line Voltage Selector Body.

A1 READ RASTER Circuit Card Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-0640-00	B010100	B109999	Complete Card
	*670-0640-01	B110000		Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C1	283-0010-00	0.05 μF	Cer	50 V	
C6	281-0525-00	470 pF	Cer	500 V	
C8	283-0655-00	0.0033 μF	Mica	500 V	1%
C10	283-0010-00	0.05 μF	Cer	50 V	
C12	281-0525-00	470 pF	Cer	500 V	
C13	281-0528-00	82 pF	Cer	500 V	10%
C17	281-0528-00	82 pF	Cer	500 V	10%
C26	281-0594-00	150 pF	Cer	100 V	5%
C41	281-0536-00	1000 pF	Cer	500 V	10%
C43	281-0525-00	470 pF	Cer	500 V	
C45	281-0523-00	100 pF	Cer	350 V	
C50	283-0655-00	0.0033 μF	Mica	500 V	1%
C61	281-0525-00	470 pF	Cer	500 V	
C71	281-0523-00	100 pF	Cer	350 V	
C80	285-0835-00	0.22 μF	PTM	100 V	2%
C85	290-0309-00	100 μF	Elect.	25 V	
C90	281-0546-00	330 pF	Cer	500 V	10%
C92	283-0623-00	1200 pF	Mica	100 V	1%
C94	281-0525-00	470 pF	Cer	500 V	
C95	283-0594-00	0.001 μF	Mica	100 V	1%
C96	281-0525-00	470 pF	Cer	500 V	
C97	283-0655-00	0.0033 μF	Mica	500 V	1%
C98	283-0623-00	1200 pF	Mica	100 V	1%
C99	283-0655-00	0.0033 μF	Mica	500 V	1%
C106	281-0523-00	100 pF	Cer	350 V	
C110	283-0594-00	0.001 μF	Mica	100 V	1%
C112	281-0525-00	470 pF	Cer	500 V	
C114	283-0655-00	0.0033 μF	Mica	500 V	1%
C121	281-0523-00	100 pF	Cer	350 V	
C124	281-0523-00	100 pF	Cer	350 V	
C127	281-0523-00	100 pF	Cer	350 V	
C131	283-0010-00	0.05 μF	Cer	50 V	
C134	281-0525-00	470 pF	Cer	500 V	
C136	281-0525-00	470 pF	Cer	500 V	
C138	283-0617-00	4700 pF	Mica	300 V	10%
C140	283-0059-00	1 μF	Cer	25 V	+80%—20%
C145	283-0655-00	10.0033 μF	Mica	500 V	1%
C150	281-0525-00	470 pF	Cer	500 V	
C162	281-0525-00	470 pF	Cer	500 V	
C175	281-0523-00	100 pF	Cer	350 V	

A1 READ RASTER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Capacitors (cont)		
C182	283-0059-00			1 μF	Cer	25 V +80%—20%
C185	283-0059-00			1 μF	Cer	25 V +80%—20%
C186	283-0059-00			1 μF	Cer	25 V +80%—20%
C190	290-0309-00			100 μF	Elect.	25 V
C197	290-0309-00			100 μF	Elect.	25 V
C199	283-0059-00			1 μF	Cer	25 V +80%—20%
				Semiconductor Device, Diodes		
CR14	152-0008-00			Germanium		
CR15	*152-0185-00			Silicon		Replaceable by 1N4152
CR18	152-0008-00			Germanium		
CR64	*152-0185-00			Silicon		Replaceable by 1N4152
CR74	*152-0185-00			Silicon		Replaceable by 1N4152
CR100	152-0008-00			Germanium		
CR101	152-0008-00			Germanium		
CR109	*152-0185-00			Silicon		Replaceable by 1N4152
CR116	152-0008-00			Germanium		
CR117	152-0008-00			Germanium		
CR118	*152-0185-00			Silicon		Replaceable by 1N4152
CR119	*152-0185-00			Silicon		Replaceable by 1N4152
CR140	152-0008-00			Germanium		
CR151	*152-0185-00			Silicon		Replaceable by 1N4152
CR153	*152-0185-00			Silicon		Replaceable by 1N4152
CR160	152-0008-00			Germanium		
CR170	152-0008-00			Germanium		
CR172	152-0008-00			Germanium		
CR173	*152-0185-00			Silicon		Replaceable by 1N4152
CR174	*152-0185-00			Silicon		Replaceable by 1N4152
VR65	152-0226-00			Zener		1N751A 400 mW, 5.1 V, 5%
VR152	152-0226-00			Zener		1N751A 400 mW, 5.1 V, 5%
				Inductors		
L46	108-0226-00			100 μH		
L93	108-0226-00			100 μH		
				Transistors		
Q45	*151-0190-02			Silicon	NPN	TO-106 Tek Spec
Q50	*151-0190-02			Silicon	NPN	TO-106 Tek Spec
Q62	*151-0261-00	B010100	B109999	Silicon	PNP	TO-78 Dual, Tek Spec
Q62	151-0188-00	B110000		Silicon	PNP	TO-92 2N3906
Q66	*151-0103-00			Silicon	NPN	TO-5 Replaceable by 2N2219
Q70	*151-0261-00			Silicon	PNP	TO-78 Dual, Tek Spec

A1 READ RASTER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
				Transistors (cont)
Q80	*151-0190-02		Silicon	NPN TO-106 Tek Spec
Q102	*151-0261-00		Silicon	PNP TO-78 Dual, Tek Spec
Q122	151-0188-00		Silicon	PNP TO-92 2N3906
Q124	*151-0190-02		Silicon	NPN TO-106 Tek Spec
Q128	*151-0190-02		Silicon	NPN TO-106 Tek Spec
Q140	*151-0192-00		Silicon	NPN TO-92 Replaceable by MPS 6521
Q158	*151-0103-00		Silicon	NPN TO-5 Replaceable by 2N2219
Q175	*151-0190-02		Silicon	NPN TO-92 Tek Spec
Q180	*151-0190-02		Silicon	NPN TO-92 Tek Spec
				Resistors
Resistors are fixed, composition, ±10% unless otherwise indicated.				
R1	315-0272-00		2.7 kΩ	1/4 W 5%
R2	315-0473-00		47 kΩ	1/4 W 5%
R4	315-0472-00		4.7 kΩ	1/4 W 5%
R6	315-0472-00		4.7 kΩ	1/4 W 5%
R8	321-0231-00		2.49 kΩ	1/8 W Prec 1%
R10	315-0103-00		10 kΩ	1/4 W 5%
R11	315-0104-00		100 kΩ	1/4 W 5%
R13	315-0470-00		47 Ω	1/4 W 5%
R14	315-0203-00		20 kΩ	1/4 W 5%
R15	315-0103-00		10 kΩ	1/4 W 5%
R17	315-0470-00		47 Ω	1/4 W 5%
R18	315-0203-00		20 kΩ	1/4 W 5%
R20	315-0104-00		100 kΩ	1/4 W 5%
R21	315-0102-00		1 kΩ	1/4 W 5%
R23	315-0203-00		20 kΩ	1/4 W 5%
R24	315-0203-00		20 kΩ	1/4 W 5%
R26	315-0562-00		5.6 kΩ	1/4 W 5%
R28	315-0681-00		680 Ω	1/4 W 5%
R32	315-0821-00		820 Ω	1/4 W 5%
R36	315-0821-00		820 Ω	1/4 W 5%
R38	315-0272-00		2.7 kΩ	1/4 W 5%
R41	315-0222-00		2.2 kΩ	1/4 W 5%
R43	315-0472-00		4.7 kΩ	1/4 W 5%
R45	315-0392-00		3.9 kΩ	1/4 W 5%
R46	321-0193-00		1 kΩ	1/8 W Prec 1%
R48	315-0202-00		2 kΩ	1/4 W 5%
R49	315-0223-00		22 kΩ	1/4 W 5%
R51	321-0419-00		226 kΩ	1/8 W Prec 1%
R55	311-0863-00		500 Ω, Var	
R58	321-0273-00		6.81 kΩ	1/8 W Prec 1%

A

A1 READ RASTER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R61	315-0392-00			3.9 kΩ	1/4 W		5%
R63	315-0751-00			750 Ω	1/4 W		5%
R64	315-0102-00			1 kΩ	1/4 W		5%
R66	321-0085-00			75 Ω	1/8 W	Prec	1%
R68	321-0066-00			47.5 Ω	1/8 W	Prec	1%
R71	315-0392-00			3.9 kΩ	1/4 W	Prec	1%
R73	315-0131-00			130 Ω	1/4 W		5%
R74	315-0102-00			1 kΩ	1/4 W		5%
R75	315-0202-00			2 kΩ	1/4 W		5%
R76	315-0223-00			22 kΩ	1/4 W		5%
R78	321-0397-00			133 kΩ	1/8 W	Prec	1%
R79	321-0381-00			90.9 kΩ	1/8 W	Prec	1%
R81	322-0469-00			750 kΩ	1/4 W	Prec	1%
R85	311-0863-00			500 Ω, Var			
R88	321-0273-00			6.81 kΩ	1/8 W	Prec	1%
R90	315-0432-00			4.3 kΩ	1/4 W		5%
R92	321-0248-00			3.74 kΩ	1/8 W	Prec	1%
R93	315-0272-00			2.7 kΩ	1/4 W		5%
R94	315-0432-00			4.3k Ω	1/4 W		5%
R95	321-0222-00			2 kΩ	(nominal value)	Selected	
R96	315-0432-00			4.3 kΩ	1/4 W		5%
R97	321-0223-00			2.05 kΩ	(nominal value)	Selected	
R98	321-0234-00			2.67 kΩ	(nominal value)	Selected	
R99	321-0243-00			3.32 kΩ	1/8 W	Prec	1%
R101	315-0332-00			3.3 kΩ	1/4 W		5%
R104	315-0512-00			5.1 kΩ	1/4 W		5%
R106	315-0392-00			3.9 kΩ	1/4 W		5%
R108	315-0131-00			130 Ω	1/4 W		5%
R109	315-0102-00			1 kΩ	1/4 W		5%
R110	321-0196-00			1.07 kΩ	1/8 W	Prec	1%
R112	315-0432-00			4.3 kΩ	1/4 W		5%
R114	321-0249-00			3.83 kΩ	1/8 W	Prec	1%
R116	315-0222-00			2.2 kΩ	1/4 W		5%
R121	315-0392-00			3.9 kΩ	1/4 W		5%
R123	315-0102-00			1 kΩ	1/4 W		5%
R125	315-0472-00			4.7 kΩ	1/4 W		5%
R126	315-0102-00			1 kΩ	1/4 W		5%
R127	315-0473-00			47 kΩ	1/4 W		5%
R129	315-0102-00			1 kΩ	1/4 W		5%
R131	315-0272-00			2.7 kΩ	1/4 W		5%
R132	315-0473-00			47 kΩ	1/4 W		5%
R133	315-0472-00			4.7 kΩ	1/4 W		5%
R135	315-0332-00			3.3 kΩ	1/4 W		5%
R136	315-0472-00			4.7 kΩ	1/4 W		5%
R138	321-0250-00			3.92 kΩ	1/8 W	Prec	1%

A1 READ RASTER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R140	315-0682-00			6.8 kΩ	1/4 W		5%
R141	315-0683-00			68 kΩ	1/4 W		5%
R143	315-0102-00			1 kΩ	1/4 W		5%
R145	321-0254-00			4.32 kΩ	(nominal value)	Selected	
R150	315-0471-00			470 Ω	1/4 W		5%
R152	315-0751-00			750 Ω	1/4 W		5%
R154	315-0102-00			1 kΩ	1/4 W		5%
R156	321-0085-00			75 Ω	1/8 W	Prec	1%
R158	321-0066-00			47.5 Ω	1/8 W	Prec	1%
R160	315-0332-00			3.3 kΩ	1/4 W		5%
R162	315-0751-00			750 Ω	1/4 W		5%
R170	315-0222-00			2.2 kΩ	1/4 W		5%
R175	315-0392-00			3.9 kΩ	1/4 W		5%
R178	315-0202-00			2 kΩ	1/4 W		5%
R180	321-0204-00			1.3 kΩ	1/8 W	Prec	1%
R182	321-0126-00			200 Ω	1/8 W	Prec	1%
R185	315-0512-00			5.1 kΩ	1/4 W		5%
				Switch			
	Wired or Unwired						
S32	260-0723-00			Slide			
				Integrated Circuits			
U3	156-0048-00			Linear, replaceable by RCA CA346			
U5	156-0021-00			Hex. inv, replaceable by Motorola MC889P			
U6	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P			
U8	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P			
U9	156-0021-00			Hex. inv, replaceable by MOT MC889P			
U30	156-0059-00			Dual J-K flip-flop, replaceable by MOT MC891P			
U32	156-0059-00			Dual J-K flip-flop, replaceable by MOT MC891P			
U34	156-0059-00			Dual J-K flip-flop, replaceable by MOT MC891P			
U36	156-0059-00			Dual J-K flip-flop, replaceable by MOT MC891P			
U38	156-0059-00			Dual J-K flip-flop, replaceable by MOT MC891P			
U39	156-0059-00			Dual J-K flip-flop, replaceable by MOT MC891P			
U41	156-0021-00			Hex. inv, replaceable by MOT MC889P			
U43	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P			
U44	156-0045-00			Triple 3-input gate, replaceable by MOT MC892P			
U45	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P			

A1 READ RASTER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
				Integrated Circuits (cont)
U46	156-0045-00			Triple 3-input gate, replaceable by MOT MC892P
U48	156-0021-00			Hex. inv, replaceable by MOT MC889P
U55	156-0049-00			Op. ampl, replaceable by Fairchild μA741C
U70	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P
U76	156-0021-00			Hex. inv, replaceable by MOT MC889P
U85	156-0049-00			Op. ampl, replaceable by Fairchild μA741C
U90	156-0045-00			Triple 3-input gate, replaceable by MOT MC892P
U92	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P
U94	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P
U110	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P
U145	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P
U147	156-0045-00			Triple 3-input gate, replaceable by MOT MC892P
				Crystals
Y13	158-0055-00			31.25 kHz
Y17	158-0049-00			31.5 kHz

A2 Z-AXIS AMPLIFIER Circuit Card Assembly

*670-1348-00 Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C201	283-0596-00	528 pF	Mica	300 V	1%
C212	283-0596-00	528 pF	Mica	300 V	1%
C240	281-0653-00	3.3 pF	Cer	200 V	±1 pF
C247	281-0653-00	3.3 pF	Cer	200 V	±1 pF
C248	283-0164-00	2.2 μF	Cer	25 V	
C249	283-0179-00	0.68 μF	Cer	100 V	10%
C251	281-0621-00	12 pF	Cer	500 V	1%
C254	283-0142-00	0.0027 μF	Cer	200 V	5%
C256	281-0139-00	2.5-9 pF, Var	Cer	100 V	
C257	281-0621-00	12 pF	Cer	500 V	1%
C264	281-0504-00	10 pF	Cer	500 V	10%
C265	283-0142-00	0.0027 μF	Cer	200 V	5%
C277	281-0661-00	0.8 pF	Cer	500 V	±0.1 pF
C278	283-0179-00	0.68 μF	Cer	100 V	10%
C300	281-0097-00	9-35 pF, Var	Cer		

A2 Z-AXIS AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C301	281-0095-00			0.2-1.5 pF, Var	Teflon		
C308	281-0523-00			100 pF	Cer	350 V	
C325	281-0524-00			150 pF	Cer	500 V	
C342	283-0177-00			1 μF	Cer	25 V	+80%—20%
C345	283-0177-00			1 μF	Cer	25 V	+80%—20%
C358	283-0177-00			1 μF	Cer	25 V	+80%—20%
C360	283-0119-00			2200 pF	Cer	200 V	5%
C370	283-0189-00			0.1 μF	Cer	400 V	
C390	283-0177-00			1 μF	Cer	25 V	+80%—20%
C391	281-0549-00			68 pF	Cer	500 V	10%
C392	283-0179-00			0.68 μF	Cer	100 V	10%
C393	290-0135-00			15 μF	Elect.	20 V	
C394	281-0549-00			68 pF	Cer	500 V	10%
C395	283-0177-00			1 μF	Cer	25 V	+80%—20%
C396	283-0177-00			1 μF	Cer	25 V	+80%—20%
C397	283-0177-00			1 μF	Cer	25 V	+80%—20%
C398	283-0164-00			2.2 μF	Cer	25 V	
C399	290-0135-00			15 μF	Elect.	20 V	
				Semiconductor Device, Diodes			
CR202	152-0246-00			Silicon	Low leakage, 250 mW, 40 V		
CR203	152-0246-00			Silicon	Low leakage, 250 mW, 40 V		
CR206	152-0246-00			Silicon	Low leakage, 200 mW, 40 V		
CR207	152-0246-00			Silicon	Low leakage, 200 mW, 40 V		
CR258	*152-0185-00			Silicon	Replaceable by 1N4152		
CR259	*152-0185-00			Silicon	Replaceable by 1N4152		
CR260	*152-0185-00			Silicon	Replaceable by 1N4152		
CR261	*152-0185-00			Silicon	Replaceable by 1N4152		
CR271	*152-0233-00			Silicon	Tek Spec		
CR272	*152-0233-00			Silicon	Tek Spec		
CR310	*152-0185-00			Silicon	Replaceable by 1N4152		
CR311	152-0008-00			Germanium			
CR312	*152-0233-00			Silicon	Tek Spec		
CR322	*152-0185-00			Silicon	Replaceable by 1N4152		
CR323	*152-0185-00			Silicon	Replaceable by 1N4152		
CR327	*152-0185-00			Silicon	Replaceable by 1N4152		
CR330	*152-0185-00			Silicon	Replaceable by 1N4152		
CR331	*152-0185-00			Silicon	Replaceable by 1N4152		
CR346	*152-0185-00			Silicon	Replaceable by 1N4152		
CR350	152-0079-00			Germanium	HD1841		

A2 Z-AXIS AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Semiconductor Device, Diodes (cont)		
CR353	152-0079-00			Germanium HD1841
CR359	*152-0185-00			Silicon Replaceable by 1N4152
CR377	*152-0185-00			Silicon Replaceable by 1N4152
VR204	152-0243-00			Zener 1N965B 400 mW, 15 V, 5%
VR205	152-0243-00			Zener 1N965B 400 mW, 15 V, 5%
VR249	152-0278-00			Zener 1N4372A 400 mW, 3 V, 5%
VR278	152-0243-00			Zener 1N965B 400 mW, 15 V, 5%
VR320	152-0279-00			Zener 1N751A 400 mW, 5.1 V, 5%
VR332	152-0279-00			Zener 1N751A 400 mW, 5.1 V, 5%
VR375	152-0212-00			Zener 1N936 500 mW, 9 V, 5% TC
VR376	152-0212-00			Zener 1N936 500 mW, 9 V, 5% TC
		Inductor		
L310	*108-0639-00			40 μH
		Transistors		
Q220	151-1036-00			Silicon FET Dual, N channel, junction type
Q234	151-0190-00			Silicon NPN TO-92 2N3904
Q285	151-0232-00			Silicon NPN TO-78 Dual
Q295	*151-0261-00			Silicon PNP TO-78 Dual, Tek Spec
Q298	151-0190-00			Silicon NPN TO-92 2N3904
Q300	151-0190-00			Silicon NPN TO-92 2N3904
Q305	*151-0124-00			Silicon NPN TO-5 Selected from 2N3119
Q308	151-0190-00			Silicon NPN TO-92 2N3904
Q310	*151-0124-00			Silicon NPN TO-5 Selected from 2N3119
Q315	*151-0228-00			Silicon PNP TO-5 Tek Spec
Q320	151-0190-00			Silicon NPN TO-92 2N3904
Q325	151-0190-00			Silicon NPN TO-92 2N3904
Q335	151-0190-00			Silicon NPN TO-92 2N3904
Q348	151-1011-00			Silicon FET Dual, N channel, junction type
Q350	151-0190-00			Silicon PNP TO-92 2N3904
Q355	151-0190-00			Silicon NPN TO-92 2N3904
Q358	151-1005-00			Silicon FET N channel, junction type
Q365	*151-0228-00			Silicon NPN TO-5 Tek Spec
Q370	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q378	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q385	151-1036-00			Silicon FET Dual, N channel, junction type
		Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.				
R201	321-0486-00			1.13 MΩ 1/8 W Prec 1%
R202	315-0204-00			200 kΩ 1/4 W 5%
R203	319-0056-00			8.5 MΩ 1/4 W Prec 1%
R204	315-0101-00			100 Ω 1/4 W 5%
R211	321-0486-00			1.13 MΩ 1/8 W Prec 1%

A2 Z-AXIS AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R212	315-0204-00			200 kΩ	1/4 W	5%
R213	319-0056-00			8.5 MΩ	1/4 W Prec	2%
R214	315-0101-00			100 Ω	1/4 W	5%
R221	321-0150-00			357 Ω	1/8 W Prec	1%
R222	321-0210-00			1.5 kΩ	1/8 W Prec	1%
R223	311-0635-00			1 kΩ, Var		
R225	321-0210-00			1.5 kΩ	1/8 W Prec	1%
R226	321-0150-00			357 Ω	1/8 W Prec	1%
R230	315-0392-00			3.9 kΩ	1/4 W	5%
R231	311-0635-00			1 kΩ, Var		
R232	315-0391-00			390 Ω	1/4 W	5%
R234	315-0201-00			200 Ω	1/4 W	5%
R236	311-0609-00			2 kΩ, Var		
R237	321-0126-00			200 Ω	1/8 W Prec	1%
R240	321-0257-00			4.64 kΩ	1/8 W Prec	1%
R241	321-0159-00			442 Ω	1/8 W Prec	1%
R242	321-0389-00			110 k	1/8 W Prec	1%
R243	321-0210-00			1.5 kΩ	1/8 W Prec	1%
R244	311-0634-00			500 Ω, Var		
R245	321-0193-00			1 kΩ	1/8 W Prec	1%
R246	321-0210-00			1.5 kΩ	1/8 W Prec	1%
R247	321-0257-00			4.64 kΩ	1/8 W Prec	1%
R248	321-0159-00			442 Ω	1/8 W Prec	1%
R249	315-0224-00			220 kΩ	1/4 W	5%
R251	321-0721-01			2.536 kΩ	1/8 W Prec	1/2%
R252	321-0339-00			33.2 kΩ	1/8 W Prec	1%
R253	315-0272-00			2.7 kΩ	1/4 W	5%
R254	321-0193-00			1 kΩ	1/8 W Prec	1%
R257	321-0721-01			2.536 kΩ	1/8 W Prec	1/2%
R258	321-0193-00			1 kΩ	1/8 W Prec	1%
R259	315-0512-00			5.1 kΩ	1/4 W	5%
R260	315-0163-00			16 kΩ	1/4 W	5%
R261	315-0822-00			8.2 kΩ	1/4 W	5%
R262	315-0272-00			2.7 kΩ	1/4 W	5%
R263	315-0361-00			360 Ω	1/4 W	5%
R264	315-0472-00			4.7 kΩ	1/4 W	5%
R265	321-0339-00			33.2 kΩ	1/8 W Prec	1%
R266	321-0235-00			2.74 kΩ	1/8 W Prec	1%
R268	321-0246-00			3.57 kΩ	1/8 W Prec	1%
R270	315-0222-00			2.2 kΩ	1/4 W	5%
R271	315-0273-00			27 kΩ	1/4 W	5%
R272	315-0821-00			820 Ω	1/4 W	5%
R274	315-0102-00			1 kΩ	1/4 W	5%
R275	315-0510-00			51 Ω	1/4 W	5%

A2 Z-AXIS AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R276	315-0332-00			3.3 kΩ	1/4 W	5%
R278	323-0135-00			249 Ω	1/8 W Prec	1%
R280	323-0140-00			280 Ω	1/2 W Prec	1%
R282	301-0471-00			470 Ω	1/2 W	5%
R284	321-0231-00			2.49 kΩ	1/8 W Prec	1%
R285	321-0149-00			348 Ω	1/8 W Prec	1%
R287	321-0152-00			374 Ω	1/8 W Prec	1%
R290	321-0132-00			232 Ω	1/8 W Prec	1%
R291	321-0132-00			232 Ω	1/8 W Prec	1%
R292	321-0246-00			3.57 kΩ	1/8 W Prec	1%
R295	321-0246-00			3.57 kΩ	1/8 W Prec	1%
R298	321-0182-00			768 Ω	1/8 W Prec	1%
R300	321-0231-00			2.49 kΩ	1/8 W Prec	1%
R301	321-0356-00			49.9 kΩ	1/8 W Prec	1%
R303	315-0561-00			560 Ω	1/4 W	5%
R305	321-0137-00			261 Ω	1/8 W Prec	1%
R307	321-0225-00			2.15 kΩ	1/8 W Prec	1%
R308	321-0193-00			1 kΩ	1/8 W Prec	1%
R310	303-0432-00			4.3 kΩ	1 W	5%
R312	315-0470-00			47 Ω	1/4 W	5%
R313	315-0750-00			75 Ω	1/4 W	5%
R314	315-0470-00			47 Ω	1/4 W	5%
R316	315-0101-00			100 Ω	1/4 W	5%
R320	315-0472-00			4.7 kΩ	1/4 W	5%
R322	315-0392-00			3.9 kΩ	1/4 W	5%
R323	315-0302-00			3 kΩ	1/4 W	5%
R325	315-0472-00			4.7 kΩ	1/4 W	5%
R327	315-0103-00			10 kΩ	1/4 W	5%
R330	315-0222-00			2.2 kΩ	1/4 W	5%
R332	315-0103-00			10 kΩ	1/4 W	5%
R335	315-0392-00			3.9 kΩ	1/4 W	5%
R336	315-0102-00			1 kΩ	1/4 W	5%
R340	321-0260-00			4.99 kΩ	1/8 W Prec	1%
R341	311-0255-00			5 kΩ, Var		
R342	321-0221-00			1.96 kΩ	1/8 W Prec	1%
R343	321-0193-00			1 kΩ	1/8 W Prec	1%
R345	315-0133-00			13 kΩ	1/4 W	5%
R346	315-0101-00			100 Ω	1/4 W	5%
R348	315-0103-00			10 kΩ	1/4 W	5%
R349	315-0103-00			10 kΩ	1/4 W	5%

A2 Z-AXIS AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R350	315-0302-00			3 kΩ	1/4 W	5%
R352	315-0222-00			2.2 kΩ	1/4 W	5%
R353	315-0562-00			5.6 kΩ	1/4 W	5%
R355	315-0122-00			1.2 kΩ	1/4 W	5%
R357	315-0202-00			2 kΩ	1/4 W	5%
R359	317-0105-00			1 MΩ	1/8 W	5%
R360	315-0102-00			1 kΩ	1/4 W	5%
R361	315-0103-00			10 kΩ	1/4 W	5%
R363	321-0260-00			4.99 kΩ	1/8 W Prec	1%
R365	321-0284-00			8.87 kΩ	1/8 W Prec	1%
R366	315-0204-00			200 kΩ	1/4 W	5%
R370	315-0102-00			1 kΩ	1/4 W	5%
R375	315-0124-00			120 kΩ	1/4 W	5%
R376	315-0243-00			24 kΩ	1/4 W	5%
R378	301-0242-00			2.4 kΩ	1/2 W	5%
R380	317-0103-00			10 kΩ	1/8 W	5%
R382	315-0103-00			10 kΩ	1/4 W	5%
R384	315-0103-00			10 kΩ	1/4 W	5%
R386	317-0103-00			10 kΩ	1/8 W	5%
R390	321-0193-00			1 kΩ	1/8 W Prec	1%
R391	317-0221-00			220 Ω	1/8 W	5%
R392	321-0193-00			1 kΩ	1/8 W Prec	1%
R394	317-0221-00			220 Ω	1/8 W	5%
R399	307-0103-00			2.7 Ω	1/4 W	5%
				Switch		
S250	260-0723-00			Slide		
				Integrated Circuits		
U245	156-0013-00			Diff comparator, replaceable by Fairchild μA710C		
U275	156-0107-00			Gate controlled two chan WB ampl, replaceable by Motorola MC1455L		
U345	156-0049-00			Op. ampl, replaceable by Fairchild μA741C		
U390	156-0108-00			Op. ampl, replaceable by RCA CA3030A		

A3 X-Y AMPLIFIER Circuit Card Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-0638-01	B100000	B119999	Complete Card
	670-0638-02	B120000		Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C401	283-0596-00	528 pF	Mica	300 V	1%
C405	283-0023-00	0.1 μF	Cer	10 V	
C411	283-0596-00	528 pF	Mica	300 V	1%
C415	283-0023-00	0.1 μF	Cer	10 V	
C416	281-0610-00	2.2 pF	Cer	200 V	±0.1 pF
C418	281-0095-00	0.2-1.5 pF, Var	Teflon		
C421	281-0610-00	2.2 pF	Cer	200 V	±0.1 pF
C423	281-0095-00	0.2-1.5 pF, Var	Teflon		
C435	283-0059-00	1 μF	Cer	25 V	+80%—20%
C444	283-0177-00	1 μF	Cer	25 V	+80%—20%
C460	281-0617-00	15 pF	Cer	200 V	
C461	281-0097-00	9-35 pF, Var	Cer		
C467	290-0420-00	0.68 μF	Elect.	75 V	
C468	281-0610-00	2.2 pF	Cer	200 V	±0.1 pF
C473	283-0059-00	1 μF	Cer	25 V	+80%—20%
C483	281-0097-00	9-35 pF, Var	Cer		
C484	281-0622-00	47 pF	Cer	500 V	1%
C487	281-0097-00	9-35 pF, Var	Cer		
C497	290-0309-00	100 μF	Elect.	25 V	
C498	290-0309-00	100 μF	Elect.	25 V	
C501	283-0596-00	528 pF	Mica	300 V	1%
C505	283-0023-00	0.1 μF	Cer	10 V	
C511	283-0596-00	528 pF	Mica	300 V	1%
C515	283-0023-00	0.1 μF	Cer	10 V	
C516	281-0615-00	3.9 pF	Cer	200 V	
C518	281-0095-00	0.2-1.5 pF, Var	Teflon		
C521	281-0615-00	3.9 pF	Cer	200 V	
C523	281-0095-00	0.2-1.5 pF, Var	Teflon		
C535	283-0059-00	1 μF	Cer	25 V	+80%—20%
C544	283-0177-00	1 μF	Cer	25 V	+80%—20%
C560	281-0617-00	15 pF	Cer	200 V	
C561	281-0097-00	9-35 pF, Var	Cer		
C567	290-0420-00	0.68 μF	Elect.	75 V	
C568	281-0610-00	2.2 pF	Cer	200 V	±0.1 pF
C573	283-0059-00	1 μF	Cer	25 V	+80%—20%
C583	281-0097-00	9-35 pF, Var	Cer		
C584	281-0622-00	47 pF	Cer	500 V	1%
C587	281-0097-00	9-35 pF, Var	Cer		
C597	290-0309-00	100 μF	Elect.	25 V	
C598	290-0309-00	100 μF	Elect.	25 V	

A3 X-Y AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Semiconductor Device, Diodes		
CR405A,B,C,D(4)	152-0246-00		Silicon	Low leakage 250 mW, 40 V
CR423	*152-0185-00		Silicon	Replaceable by 1N4152
CR456	*152-0316-00		Silicon	Assembly, Tek Spec
CR457	*152-0185-00		Silicon	Replaceable by 1N4152
CR458	*152-0316-00		Silicon	Assembly, Tek Spec
CR459	*152-0185-00		Silicon	Replaceable by 1N4152
CR505A,B,C,D(4)	152-0246-00		Silicon	Low leakage, 250 mW, 40 V
CR523	*152-0185-00		Silicon	Replaceable by 1N4152
CR556	*152-0316-00		Silicon	Assembly, Tek Spec
CR557	*152-0185-00		Silicon	Replaceable by 1N4152
CR558	*152-0316-00		Silicon	Assembly, Tek Spec
CR559	*152-0185-00		Silicon	Replaceable by 1N4152
VR424	152-0306-00		Zener	1N960B 400 mW, 9.1 V, 5%
VR428	152-0306-00		Zener	1N960B 400 mW, 9.1 V, 5%
VR435	152-0124-00		Zener	1N938A 500 mW, 9.1 V, 5% TC
VR524	152-0306-00		Zener	1N960B 400 mW, 9.1 V, 5%
VR528	152-0306-00		Zener	1N960B 400 mW, 9.1 V, 5%
VR535	152-0124-00		Zener	1N938A 500 mW, 9.1 V, 5% TC
		Connectors		
J400	131-0754-00		Receptacle, electrical	
J410	131-0754-00		Receptacle, electrical	
J500	131-0754-00		Receptacle, electrical	
J510	131-0754-00		Receptacle, electrical	
		Transistors		
Q405	*151-1036-00		Silicon FET	Dual, Tek Spec
Q430	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q445	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q455	151-0188-00		Silicon PNP	TO-92 2N3906
Q460	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q470	151-0232-00		Silicon NPN	TO-78 Dual
Q475	151-0232-00		Silicon NPN	TO-78 Dual
Q478	*151-0103-00		Silicon NPN	TO-5 Replaceable by 2N2219
Q488	*151-0103-00		Silicon NPN	TO-5 Replaceable by 2N2219
Q505	*151-1036-00		Silicon FET	Dual, Tek Spec
Q530	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q545	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q555	151-0188-00		Silicon PNP	TO-92 2N3906
Q560	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q570	151-0232-00		Silicon NPN	TO-78 Dual

A3 X-Y AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Transistors (cont)		
Q575	151-0232-00			Silicon NPN TO-78 Dual
Q578	*151-0103-00			Silicon NPN TO-5 Replaceable by 2N2219
Q588	*151-0103-00			Silicon NPN TO-5 Replaceable by 2N2219
		Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.				
R400	321-0486-00			1.13 MΩ 1/8 W Prec 1%
R401	315-0204-00			200 kΩ 1/4 W 5%
R402	315-0101-00			100 Ω 1/4 W 5%
R403	319-0056-00			8.5 MΩ 1/4 W 2%
R404	315-0470-00			47 Ω 1/4 W 5%
R405	315-0100-00			10 Ω 1/4 W 5%
R407	321-0245-00			3.48 kΩ 1/8 W Prec 1%
R408	311-0807-00			1 kΩ, Var
R410	321-0486-00			1.13 MΩ 1/8 W Prec 1%
R411	315-0204-00			200 kΩ 1/4 W 5%
R412	315-0101-00			100 Ω 1/4 W 5%
R413	319-0056-00			8.5 MΩ 1/4 W 2%
R415	315-0100-00			10 Ω 1/4 W 5%
R416	321-0261-00			5.11 kΩ 1/8 W Prec 1%
R417	321-0245-00			3.48 kΩ 1/8 W Prec 1%
R418	321-0326-00			24.3 kΩ 1/8 W Prec 1%
R420	311-0940-00			2.5 kΩ, Var
R421	321-0249-00			3.83 kΩ 1/8 W Prec 1%
R422	321-0356-00			49.9 kΩ 1/8 W Prec 1%
R423	321-0326-00			24.3 kΩ 1/8 W Prec 1%
R424	315-0751-00			750 Ω 1/4 W 5%
R425	321-0242-00			3.24 kΩ 1/8 W Prec 1%
R426	321-0239-00			3.01 kΩ 1/8 W Prec 1%
R427	321-0239-00			3.01 kΩ 1/8 W Prec 1%
R428	315-0471-00			470 Ω 1/4 W 5%
R430	321-0131-00			226 Ω 1/8 W Prec 1%
R431	321-0131-00			226 Ω 1/8 W Prec 1%
R433	321-0222-00			2 kΩ 1/8 W Prec 1%
R434	321-0222-00			2 kΩ 1/8 W Prec 1%
R435	315-0241-00			240 Ω 1/4 W 5%
R436	315-0332-00			3.3 kΩ 1/4 W 5%
R437	315-0332-00			3.3 kΩ 1/4 W 5%
R438	311-0807-00			1 kΩ, Var
R439	321-0215-00			1.69 kΩ 1/8 W Prec 1%
R440	321-0356-00			49.9 kΩ 1/8 W Prec 1%

A3 X-Y AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R442	321-0165-00			511 Ω	1/8 W	Prec	1%
R443	321-0193-00			1 kΩ	1/8 W	Prec	1%
R444	321-0167-00			536 Ω	1/8 W	Prec	1%
R445	321-0326-00			24.3 kΩ	1/8 W	Prec	1%
R447	321-0187-00			866 Ω	1/8 W	Prec	1%
R448	321-0258-00			4.75 kΩ	1/8 W	Prec	1%
R449	311-0901-00			250 Ω, Var			
R455	315-0332-00			3.3 kΩ	1/4 W		5%
R456	315-0682-00			6.8 kΩ	1/4 W		5%
R457	315-0103-00			10 kΩ	1/4 W		5%
R458	315-0682-00			6.8 kΩ	1/4 W		5%
R460	321-0245-00			3.48 kΩ	1/8 W	Prec	1%
R461	321-0226-00			2.21 kΩ	1/8 W	Prec	1%
R462	311-0940-00			2.5 kΩ, Var			
R463	321-0246-00			3.57 kΩ	1/8 W	Prec	1%
R464	321-0246-00			3.57 kΩ	1/8 W	Prec	1%
R465	321-0281-00			8.25 kΩ	1/8 W	Prec	1%
R466	321-0281-00			8.25 kΩ	1/8 W	Prec	1%
R467	315-0100-00			10 Ω	1/4 W		5%
R468	323-0251-00			4.02 kΩ	1/2 W	Prec	1%
R469	323-0251-00			4.02 kΩ	1/2 W	Prec	1%
R470	321-0202-00			1.24 kΩ	1/8 W	Prec	1%
R471	315-0271-00			270 Ω	1/4 W		5%
R472	315-0122-00			1.2 kΩ	1/4 W		5%
R473	323-0130-00			221 Ω	1/2 W	Prec	1%
R474	311-0863-00			500 Ω, Var		Prec	1%
R475	321-0286-00			9.31 kΩ	1/8 W	Prec	1%
R477	311-0902-00			5 kΩ, Var			
R478	321-0108-00			130 Ω	1/8 W	Prec	1%
R479	321-0269-00			6.19 kΩ	1/8 W	Prec	1%
R480	321-0202-00			1.24 kΩ	1/8 W	Prec	1%
R481	315-0271-00			270 Ω	1/4 W		5%
R482	315-0122-00			1.2 kΩ	1/4 W		5%
R483	323-0130-00			221 Ω	1/2 W	Prec	1%
R484	321-0089-00			82.5 Ω	1/8 W	Prec	1%
R485	321-0286-00			9.31 kΩ	1/8 W	Prec	1%
R488	321-0108-00			130 Ω	1/8 W	Prec	1%
R489	321-0269-00			6.19 kΩ	1/8 W	Prec	1%
R498	315-0470-00			47 Ω	1/4 W		5%
R500	321-0486-00			1.13 MΩ	1/8 W	Prec	1%
R501	315-0204-00			200 kΩ	1/4 W		5%
R502	315-0101-00			100 Ω	1/4 W		5%
R503	319-0056-00			8.5 MΩ	1/4 W		2%
R504	315-0470-00			47 Ω	1/4 W		5%
R505	315-0100-00			10 Ω	1/4 W		5%
R507	321-0245-00			3.48 kΩ	1/8 W	Prec	1%
R508	311-0807-00			1 kΩ, Var			

A3 X-Y AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Resistors (cont)			
R510	321-0486-00			1.13 MΩ	1/8 W	Prec 1%
R511	315-0204-00			200 kΩ	1/4 W	5%
R512	315-0101-00			100 Ω	1/4 W	5%
R513	319-0056-00			8.5 MΩ	1/4 W	2%
R515	315-0100-00			10 Ω	1/4 W	5%
R516	321-0261-00			5.11 kΩ	1/8 W	Prec 1%
R517	321-0245-00			3.48 kΩ	1/8 W	Prec 1%
R518	321-0326-00			24.3 kΩ	1/8 W	Prec 1%
R520	311-0940-00			2.5 kΩ, Var		
R521	321-0249-00			3.83 kΩ	1/8 W	Prec 1%
R522	321-0356-00			49.9 kΩ	1/8 W	Prec 1%
R523	321-0326-00			24.3 kΩ	1/8 W	Prec 1%
R524	315-0751-00			750 Ω	1/4 W	5%
R525	321-0242-00			3.24 kΩ	1/8 W	Prec 1%
R526	321-0239-00			3.01 kΩ	1/8 W	Prec 1%
R527	321-0239-00			3.01 kΩ	1/8 W	Prec 1%
R528	315-0471-00			470 Ω	1/4 W	5%
R530	321-0131-00			226 Ω	1/8 W	Prec 1%
R531	321-0131-00			226 Ω	1/8 W	Prec 1%
R533	321-0222-00			2 kΩ	1/8 W	Prec 1%
R534	321-0222-00			2 kΩ	1/8 W	Prec 1%
R535	315-0241-00			240 Ω	1/4 W	5%
R536	315-0332-00			3.3 kΩ	1/4 W	5%
R537	315-0332-00			3.3 kΩ	1/4 W	5%
R538	311-0807-00			1 kΩ, Var		
R539	321-0215-00			1.69 kΩ	1/8 W	Prec 1%
R540	321-0356-00			49.9 kΩ	1/8 W	Prec 1%
R542	321-0165-00			511 Ω	1/8 W	Prec 1%
R543	321-0193-00			1 kΩ	1/8 W	Prec 1%
R544	321-0167-00			536 Ω	1/8 W	Prec 1%
R545	321-0326-00			24.3 kΩ	1/8 W	Prec 1%
R547	321-0187-00			866 Ω	1/8 W	Prec 1%
R548	321-0258-00			4.75 kΩ	1/8 W	Prec 1%
R549	311-0901-00			250 Ω, Var		
R555	315-0332-00			3.3 kΩ	1/4 W	5%
R556	315-0682-00			6.8 kΩ	1/4 W	5%
R557	315-0103-00			10 kΩ	1/4 W	5%
R558	315-0682-00			6.8 kΩ	1/4 W	5%
R560	321-0245-00			3.48 kΩ	1/8 W	Prec 1%
R561	321-0201-00			1.21 kΩ	1/8 W	Prec 1%
R562	311-0940-00			2.5 kΩ, Var		
R563	321-0246-00			3.57 kΩ	1/8 W	Prec 1%
R564	321-0246-00			3.57 kΩ	1/8 W	Prec 1%
R565	321-0281-00			8.25 kΩ	1/8 W	Prec 1%
R566	321-0281-00			8.25 kΩ	1/8 W	Prec 1%

A3 X-Y AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Resistors (cont)			
R567	315-0100-00		10 Ω	1/4 W		5%
R568	323-0251-00		4.02 kΩ	1/2 W	Prec	1%
R569	323-0251-00		4.02 kΩ	1/2 W	Prec	1%
R570	321-0202-00		1.24 kΩ	1/8 W	Prec	1%
R571	315-0271-00		270 Ω	1/4 W		5%
R572	315-0122-00		1.2 kΩ	1/4 W		5%
R573	323-0130-00		221 Ω	1/2 W	Prec	1%
R574	311-0863-00		500 Ω, Var			
R575	321-0286-00		9.31 kΩ	1/8 W	Prec	1%
R577	311-0902-00		5 kΩ, Var			
R578	321-0108-00		130 Ω	1/8 W	Prec	1%
R579	321-0269-00		6.19 kΩ	1/8 W	Prec	1%
R580	321-0202-00		1.24 kΩ	1/8 W	Prec	1%
R581	315-0271-00		270 Ω	1/4 W		5%
R582	315-0122-00		1.2 kΩ	1/4 W		5%
R583	323-0130-00		221 Ω	1/2 W	Prec	1%
R584	321-0089-00		82.5 Ω	1/8 W	Prec	1%
R585	321-0286-00		9.31 kΩ	1/8 W	Prec	1%
R588	321-0108-00		130 Ω	1/8 W	Prec	1%
R589	321-0269-00		6.19 kΩ	1/8 W	Prec	1%
R598	315-0470-00		47 Ω	1/4 W		5%
			Integrated Circuits			
U425	156-0048-00		Linear, replaceable by RCA CA3046			
U525	156-0048-00		Linear, replaceable by RCA CA3046			

A4 STORAGE Circuit Card Assembly

*670-0641-02	Complete Card	

Capacitors

Tolerance ±20% unless otherwise indicated.

C602	281-0536-00	1000 pF	Cer	500 V	10%
C604	283-0081-00	0.1 μF	Cer	25 V	+80%—20%
C612	283-0010-00	0.05 μF	Cer	50 V	
C614	290-0246-00	3.3 μF	Elect.	15 V	10%
C615	281-0546-00	330 pF	Cer	500 V	10%
C618	290-0135-02	15 μF	Elect.	20 V	
C630	281-0523-00	100 pF	Cer	350 V	
C634	290-0136-00	2.2 μF	Elect.	20 V	
C635	290-0167-00	10 μF	Elect.	15 V	
C636	290-0177-00	1 μF	Elect.	50 V	

A4 STORAGE Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C641	283-0026-00			0.2 μF	Cer	25 V	
C644	290-0187-00			4.7 μF	Elect.	35 V	
C651	281-0519-00			47 pF	Cer	500 V	10%
C655	290-0167-00			10 μF	Elect.	15 V	
C658	283-0164-00			2.2 μF	Cer	25 V	
C664	283-0078-00			0.001 μF	Cer	500 V	
C665	281-0546-00			330 pF	Cer	500 V	10%
C668	283-0164-00			2.2 μF	Cer	25 V	
C672	281-0614-00			6800 pF	Cer	500 V	+80%—20%
C674	283-0078-00			0.001 μF	Cer	500 V	
C687	283-0008-00			0.1 μF	Cer	500 V	
C690	290-0164-00			1 μF	Elect.	150 V	
C693	283-0008-00			0.1 μF	Cer	500 V	
C695	283-0008-00			0.1 μF	Cer	500 V	
C696	290-0136-00			2.2 μF	Elect.	20 V	
C697	290-0247-00			5.6 μF	Elect.	6 V	
C698	290-0136-00			2.2 μF	Elect.	20 V	
				Semiconductor Device, Diodes			
CR602	*152-0185-00			Silicon	Replaceable by 1N4152		
CR603	*152-0185-00			Silicon	Replaceable by 1N4152		
CR604	*152-0185-00			Silicon	Replaceable by 1N4152		
CR606	152-0008-00			Germanium			
CR620	152-0008-00			Germanium			
CR621	152-0008-00			Germanium			
CR622	152-0008-00			Germanium			
CR624	152-0008-00			Germanium			
CR625	152-0008-00			Germanium			
CR628	*152-0185-00			Silicon	Replaceable by 1N4152		
CR632	*152-0185-00			Silicon	Replaceable by 1N4152		
CR636	*152-0185-00			Silicon	Replaceable by 1N4152		
CR645	*152-0185-00			Silicon	Replaceable by 1N4152		
CR648	*152-0185-00			Silicon	Replaceable by 1N4152		
CR649	*152-0185-00			Silicon	Replaceable by 1N4152		
CR653	*152-0185-00			Silicon	Replaceable by 1N4152		
CR654	*152-0185-00			Silicon	Replaceable by 1N4152		
CR655	*152-0185-00			Silicon	Replaceable by 1N4152		
CR656	*152-0185-00			Silicon	Replaceable by 1N4152		
CR659	*152-0185-00			Silicon	Replaceable by 1N4152		

A4 STORAGE Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Semiconductor Device, Diodes (cont)		
CR663	*152-0185-00			Silicon Replaceable by 1N4152
CR664	*152-0185-00			Silicon Replaceable by 1N4152
CR670	*152-0061-00			Silicon Tek Spec
CR672	*152-0061-00			Silicon Tek Spec
CR678	*152-0185-00			Silicon Replaceable by 1N4152
CR682	*152-0061-00			Silicon Tek Spec
VR641	152-0127-00			Zener 1N755A 400 mW, 7.5 V, 5%
VR680	152-0305-00			Zener 1N3045B 1 W, 110 V, 5%
VR690	152-0087-00			Zener 1N3044B 1 W, 100 V, 5%
		Relays		
K645-L1	*108-0355-00			Reed Drive
K645-S1	260-0721-00			Reed
		Transistors		
Q615	*151-0228-00			Silicon PNP TO-5 Tek Spec
Q625	151-0190-00			Silicon NPN TO-92 2N3904
Q630	151-0188-00			Silicon PNP TO-92 2N3906
Q640	151-0188-00			Silicon PNP TO-92 2N3906
Q642	151-0188-00			Silicon PNP TO-92 2N3906
Q645	151-0188-00			Silicon PNP TO-92 2N3906
Q650	151-0190-00			Silicon NPN TO-92 2N3904
Q655	151-0188-00			Silicon PNP TO-92 2N3906
Q665	151-0169-00			Silicon NPN TO-5 2N3439
Q670	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q675	151-0169-00			Silicon NPN TO-5 2N3439
Q678	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q680	151-0169-00			Silicon NPN TO-5 2N3439
Q685	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
		Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.				
R602	315-0105-00			1 MΩ 1/4 W 5%
R604	315-0332-00			3.3 kΩ 1/4 W 5%
R606	315-0272-00			2.7 kΩ 1/4 W 5%
R612	315-0511-00			510 Ω 1/4 W 5%
R614	321-0246-00			3.57 kΩ 1/8 W Prec 1%

[A]

A4 STORAGE Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Resistors (cont)			
R615	315-0102-00			1 kΩ	1/4 W	5%
R616	315-0511-00			510 Ω	1/4 W	5%
R618	321-0255-00			4.42 kΩ	1/8 W Prec	1%
R621	315-0153-00			15 kΩ	1/4 W	5%
R625	315-0471-00			470 Ω	1/4 W	5%
R627	315-0102-00			1 kΩ	1/4 W	5%
R628	315-0512-00			5.1 kΩ	1/4 W	5%
R629	315-0103-00			10 kΩ	1/4 W	5%
R630	321-0300-00			13 kΩ	1/8 W Prec	1%
R632	323-0411-00			187 kΩ	1/2 W Prec	1%
R634	315-0470-00			47 Ω	1/4 W	5%
R635	315-0162-00			1.6 kΩ	1/4 W	5%
R636	321-0402-00			150 kΩ	1/8 W Prec	1%
R637	315-0103-00			10 kΩ	1/4 W	5%
R639	315-0332-00			3.3 kΩ	1/4 W	5%
R640	315-0821-00			820 Ω	1/4 W	5%
R641	315-0104-00			100 kΩ	1/4 W	5%
R643	315-0162-00			1.6 kΩ	1/4 W	5%
R644	311-0902-00			5 kΩ, Var		
R645	311-0902-00			5 kΩ, Var		
R646	315-0301-00			300 Ω	1/4 W	5%
R648	315-0512-00			5.1 kΩ	1/4 W	5%
R649	315-0512-00			5.1 kΩ	1/4 W	5%
R651	315-0102-00			1 kΩ	1/4 W	5%
R653	315-0512-00			5.1 kΩ	1/4 W	5%
R655	315-0105-00			1 MΩ	1/4 W	5%
R657	315-0243-00			24 kΩ	1/4 W	5%
R658	315-0243-00			24 kΩ	1/4 W	5%
R659	315-0104-00			100 kΩ	1/4 W	5%
R664	315-0102-00			1 kΩ	1/4 W	5%
R665	315-0102-00			1 kΩ	1/4 W	5%
R666	305-0104-00			100 kΩ	2 W	5%
R668	315-0682-00			6.8 kΩ	1/4 W	5%
R670	315-0511-00			510 Ω	1/4 W	5%
R671	315-0101-00			100 Ω	1/4 W	5%
R673	323-0438-00			357 kΩ	1/2 W Prec	1%
R674	315-0203-00			20 kΩ	1/4 W	5%
R675	321-0267-00			5.9 kΩ	1/8 W Prec	1%
R677	315-0102-00			1 kΩ	1/4 W	5%
R678	315-0153-00			15 kΩ	1/4 W	5%
R682	311-0903-00			1 MΩ, Var		
R684	301-0104-00			100 kΩ	1/2 W	5%
R685	315-0101-00			100 Ω	1/4 W	5%
R687	311-0903-00			1 MΩ, Var		
R689	301-0104-00			100 kΩ	1/2 W	5%

A4 STORAGE Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R690	315-0204-00			200 kΩ	1/4 W	5%
R692	311-0903-00			1 MΩ, Var		
R693	315-0274-00			270 kΩ	1/4 W	5%
R695	315-0101-00			100 Ω	1/4 W	5%
R696	307-0023-00			4.7 Ω	1/2 W	
R697	315-0270-00			27 Ω	1/4 W	5%
R698	307-0023-00			4.7 Ω	1/2 W	
				Integrated Circuits		
U610	156-0021-00			Hex. inv, replaceable by MOT MC889P		
U660	156-0049-00			Op. ampl, replaceable by Fairchild μA741C		

A5 READ AMPLIFIER Circuit Card Assembly

*670-1369-00	B010100	B129999	Complete Card
*670-1369-01	B130000		Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C701	281-0614-00	6800 pF	Cer	500 V	+80%—20%
C702	283-0068-00	0.01 μF	Cer	500 V	
C703	283-0189-00	0.1 μF	Cer	400 V	
C704	283-0177-00	1 μF	Cer	25 V	+80%—20%
C706	283-0177-00	1 μF	Cer	25 V	+80%—20%
C707	283-0164-00	2.2 μF	Cer	25 V	
C712	283-0203-00	0.47 μF	Cer	50 V	
C714	283-0177-00	1 μF	Cer	25 V	+80%—20%
C716	281-0523-00	100 pF	Cer	350 V	
C728	283-0177-00	1 μF	Cer	25 V	+80%—20%
C730	283-0177-00	1 μF	Cer	25 V	+80%—20%
C732	283-0177-00	1 μF	Cer	25 V	+80%—20%
C736	283-0177-00	1 μF	Cer	25 V	+80%—20%
C737	283-0114-00	0.0015 μF	Cer	200 V	5%
C738	283-0114-00	0.0015 μF	Cer	200 V	5%
C740	283-0177-00	1 μF	Cer	25 V	+80%—20%
C745	283-0177-00	1 μF	Cer	25 V	+80%—20%
C750	283-0177-00	1 μF	Cer	25 V	+80%—20%
C757	283-0177-00	1 μF	Cer	25 V	+80%—20%
C759	283-0177-00	1 μF	Cer	25 V	+80%—20%

A5 READ AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Capacitors (cont)			
C765	283-0177-00		1 μF	Cer	25 V	+80%—20%
C767	283-0111-00		0.1 μF	Cer	50 V	
C775	283-0111-00		0.1 μF	Cer	50 V	
C777	283-0177-00		1 μF	Cer	25 V	+80%—20%
C783	283-0177-00		1 μF	Cer	25 V	+80%—20%
C784	283-0177-00		1 μF	Cer	25 V	+80%—20%
C803	283-0167-00	XB130000	0.1 μF	Cer	100 V	10%
C810	283-0177-00		1 μF	Cer	25 V	+80%—20%
C820	281-0592-00		4.7 pF	Cer	500 V	±0.5 pF
C823	281-0513-00		27 pF	Cer	500 V	
C833	283-0164-00		2.2 pF	Cer	25 V	
C837	281-0557-00		1.8 pF	Cer	500 V	
C853	281-0511-00		22 pF	Cer	500 V	10%
C867	283-0164-00		2.2 pF	Cer	25 V	
C872	283-0070-00		30 pF	Cer	50 V	10%
C876	283-0178-00		0.1 μF	Cer	100 V	+80%—20%
C883	281-0511-00		22 pF	Cer	500 V	10%
C890	283-0059-00		1 μF	Cer	25 V	+80%—20%
C891	290-0309-00		100 μF	Elect.	25 V	
C892	283-0177-00		1 μF	Cer	25 V	+80%—20%
C894	283-0177-00		1 μF	Cer	25 V	+80%—20%
C896	283-0177-00		1 μF	Cer	25 V	+80%—20%
C897	290-0309-00		100 pF	Cer	25 V	
C898	283-0177-00		1 μF	Cer	25 V	+80%—20%
			Semiconductor Device, Diodes			
CR703	*152-0107-00		Silicon	Replaceable by 1N647		
CR705	*152-0107-00		Silicon	Replaceable by 1N647		
CR708	*152-0185-00		Silicon	Replaceable by 1N4152		
CR709	*152-0185-00		Silicon	Replaceable by 1N4152		
CR741	*152-0269-00		Silicon	Volt. var cap. Tek Spec		
CR742	*152-0269-00		Silicon	Volt. var cap. Tek Spec		
CR780	*152-0185-00		Silicon	Replaceable by 1N4152		
CR781	*152-0185-00		Silicon	Replaceable by 1N4152		
CR797	*152-0185-00		Silicon	Replaceable by 1N4152		
CR800	*152-0185-00		Silicon	Replaceable by 1N4152		
CR801	*152-0185-00		Silicon	Replaceable by 1N4152		
CR802	*152-0185-00		Silicon	Replaceable by 1N4152		
CR803	152-0008-00	XB130000	Germanium			
CR805	*152-0185-00		Silicon	Replaceable by 1N4152		
CR806	*152-0185-00		Silicon	Replaceable by 1N4152		
CR815	152-0008-00		Germanium			

A5 READ AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Capacitors (cont)		
CR817	*152-0185-00		Silicon	Replaceable by 1N4152
CR845	*152-0185-00		Silicon	Replaceable by 1N4152
CR846	*152-0185-00		Silicon	Replaceable by 1N4152
CR851	*152-0185-00		Silicon	Replaceable by 1N4152
CR863	*152-0185-00		Silicon	Replaceable by 1N4152
CR866	*152-0185-00		Silicon	Replaceable by 1N4152
CR878	*152-0185-00		Silicon	Replaceable by 1N4152
CR880	*152-0185-00		Silicon	Replaceable by 1N4152
VR730	152-0278-00		Zener	1N4372A 400 mW, 3 V, 5%
VR757	152-0243-00		Zener	1N965B 400 mW, 15 V, 5%
VR792	152-0217-00		Zener	1N756A 400 mW, 8.2 V, 5%
VR833	152-0127-00		Zener	1N755A 400 mW, 7.5 V, 5%
		Connectors		
J700	131-0754-00		Receptacle, electrical	
J838	131-0391-00		Receptacle, electrical, coaxial, snap-on male	
		Inductor		
L725	*114-0304-00		1.4-3.2 μH, Var	Core 276-0506-00
		Transistors		
Q705	151-1005-00		Silicon FET	N channel, junction type
Q710	151-0190-00		Silicon NPN	TO-92 2N3904
Q732	151-0188-00		Silicon PNP	TO-92 2N3906
Q740	151-1005-00		Silicon FET	N channel, junction type
Q745	151-1005-00		Silicon FET	N channel, junction type
Q750	151-1036-00		Silicon FET	Dual, N channel, junction type
Q760	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q765	151-0232-00		Silicon NPN	TO-78 Dual
Q770	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q780	151-1005-00		Silicon FET	N channel, junction type
Q787	151-0190-00		Silicon NPN	TO-92 2N3904
Q790	151-0190-00		Silicon NPN	TO-92 2N3904
Q795	151-0190-00		Silicon NPN	TO-92 2N3904
Q800	*151-0261-00		Silicon PNP	TO-78 Dual, Tek Spec
Q810	151-0188-00		Silicon PNP	TO-92 2N3906

A5 READ AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Description
				Transistors (cont)
Q815	151-0190-00			Silicon NPN TO-92 2N3904
Q820	151-0190-00			Silicon NPN TO-92 2N3904
Q840	151-0190-00			Silicon NPN TO-92 2N3904
Q842	151-0190-00			Silicon NPN TO-92 2N3904
Q845	151-0188-00			Silicon PNP TO-92 2N3906
Q850	151-0190-00			Silicon NPN TO-92 2N3904
				Resistors
Resistors are fixed, composition, ±10% unless otherwise indicated.				
R701	315-0240-00			24 Ω 1/4 W 5%
R702	315-0512-00			5.1 kΩ 1/4 W 5%
R703	315-0512-00			5.1 kΩ 1/4 W 5%
R704	315-0510-00			51 Ω 1/4 W 5%
R705	315-0104-00			100 kΩ 1/4 W 5%
R706	315-0242-00			2.4 kΩ 1/4 W 5%
R707	315-0102-00			1 kΩ 1/4 W 5%
R708	315-0474-00			470 kΩ 1/4 W 5%
R709	315-0103-00			10 kΩ 1/4 W 5%
R711	315-0102-00			1 kΩ 1/4 W 5%
R712	315-0152-00			1.5 kΩ 1/4 W 5%
R713	315-0162-00			1.6 kΩ 1/4 W 5%
R714	315-0470-00			47 Ω 1/4 W 5%
R715	315-0302-00			3 kΩ 1/4 W 5%
R716	315-0301-00			300 Ω 1/4 W 5%
R718	315-0302-00			3 kΩ 1/4 W 5%
R719	315-0302-00			3 kΩ 1/4 W 5%
R720	315-0470-00			47 Ω 1/4 W 5%
R721	315-0272-00			2.7 kΩ 1/4 W 5%
R725	315-0121-00			120 Ω 1/4 W 5%
R727	315-0472-00			4.7 kΩ 1/4 W 5%
R728	315-0822-00			8.2 kΩ 1/4 W 5%
R730	315-0103-00			10 kΩ 1/4 W 5%
R731	315-0470-00			47 Ω 1/4 W 5%
R732	315-0153-00			15 kΩ 1/4 W 5%
R733	315-0512-00			5.1 kΩ 1/4 W 5%
R734	315-0272-00			2.7 kΩ 1/4 W 5%
R735	315-0153-00			15 kΩ 1/4 W 5%
R736	315-0103-00			10 kΩ 1/4 W 5%
R737	315-0103-00			10 kΩ 1/4 W 5%
R740	315-0102-00			1 kΩ 1/4 W 5%
R741	315-0105-00			1 MΩ 1/4 W 5%
R743	315-0105-00			1 MΩ 1/4 W 5%
R745	315-0102-00			1 kΩ 1/4 W 5%
R746	311-0633-00			5 kΩ, Var

A5 READ AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
			Resistors (cont)		
R747	315-0332-00		3.3 kΩ	1/4 W	5%
R750	315-0511-00		510 Ω	1/4 W	5%
R751	315-0302-00		3 kΩ	1/4 W	5%
R752	315-0152-00		1.5 kΩ	1/4 W	5%
R753	315-0911-00		910 Ω	1/4 W	5%
R754	315-0152-00		1.5 kΩ	1/4 W	5%
R755	315-0302-00		3 kΩ	1/4 W	5%
R757	315-0431-00		430 Ω	1/4 W	5%
R759	315-0301-00		300 Ω	1/4 W	5%
R760	315-0471-00		470 Ω	1/4 W	5%
R761	315-0512-00		5.1 kΩ	1/4 W	5%
R763	315-0241-00		240 Ω	1/4 W	5%
R764	315-0103-00		10 kΩ	1/4 W	5%
R765	315-0103-00		10 kΩ	1/4 W	5%
R766	315-0121-00		120 Ω	1/4 W	5%
R767	315-0153-00		15 kΩ	1/4 W	5%
R768	315-0221-00		220 Ω	1/4 W	5%
R769	315-0152-00		1.5 kΩ	1/4 W	5%
R771	315-0152-00		1.5 kΩ	1/4 W	5%
R772	315-0221-00		220 Ω	1/4 W	5%
R774	315-0133-00		13 kΩ	1/4 W	5%
R775	315-0511-00		510 Ω	1/4 W	5%
R777	315-0470-00		47 Ω	1/4 W	5%
R778	315-0221-00		220 Ω	1/4 W	5%
R780	315-0683-00		68 kΩ	1/4 W	5%
R781	315-0104-00		100 kΩ	1/4 W	5%
R782	311-0644-00		20 kΩ, Var		
R783	315-0105-00		1 MΩ	1/4 W	5%
R784	315-0105-00		1 MΩ	1/4 W	5%
R785	315-0104-00		100 kΩ	1/4 W	5%
R786	315-0622-00		6.2 kΩ	1/4 W	5%
R787	315-0133-00		13 kΩ	1/4 W	5%
R792	315-0752-00		7.5 kΩ	1/4 W	5%
R794	315-0102-00		1 kΩ	1/4 W	5%
R795	315-0153-00		15 kΩ	1/4 W	5%
R797	315-0103-00		10 kΩ	1/4 W	5%
R798	311-0614-00		30 kΩ, Var		
R800	315-0512-00		5.1 kΩ	1/4 W	5%
R801	315-0511-00	XB130000	510 Ω	1/4 W	5%
R802	315-0301-00		300 Ω	1/4 W	5%
R803	315-0222-00		2.2 kΩ	1/4 W	5%
R804	315-0162-00		1.6 kΩ	1/4 W	5%
R805	315-0511-00	XB130000	510 Ω	1/4 W	5%
R806	315-0302-00		3 kΩ	1/4 W	5%
R807	315-0431-00		430 Ω	1/4 W	5%
R808	315-0752-00		7.5 kΩ	1/4 W	5%

A5 READ AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors (cont)		
R810	315-0222-00			2.2 kΩ	1/4 W	5%
R811	315-0202-00			2 kΩ	1/4 W	5%
R812	315-0223-00			22 kΩ	1/4 W	5%
R813	315-0163-00			16 kΩ	1/4 W	5%
R815	315-0102-00			1 kΩ	1/4 W	5%
R816	315-0153-00			15 kΩ	1/4 W	5%
R817	315-0272-00			2.7 kΩ	1/4 W	5%
R820	315-0431-00			430 Ω	1/4 W	5%
R822	321-0227-00			2.26 kΩ	1/8 W Prec	1%
R823	315-0750-00			75 Ω	1/4 W	5%
R824	315-0102-00			1 kΩ	1/4 W	5%
R825	315-0102-00			1 kΩ	1/4 W	5%
R826	315-0202-00			2 kΩ	1/4 W	5%
R827	321-0239-00			3.01 kΩ	1/8 W Prec	1%
R828	321-0210-00			1.5 kΩ	1/8 W Prec	1%
R830	315-0101-00			100 Ω	1/4 W	5%
R831	315-0512-00			5.1 kΩ	1/4 W	5%
R833	315-0510-00			51 Ω	1/4 W	5%
R835	321-0239-00			3.01 kΩ	1/8 W Prec	1%
R836	321-0239-00			3.01 kΩ	1/8 W Prec	1%
R837	315-0752-00			7.5 kΩ	1/4 W	5%
R838	301-0751-00			750 Ω	1/2 W	5%
R839	321-0085-00			75 Ω	1/8 W Prec	1%
R840	315-0202-00			2 kΩ	1/4 W	5%
R842	315-0302-00			3 kΩ	1/4 W	5%
R844	315-0752-00			7.5 kΩ	1/4 W	5%
R845	315-0392-00			3.9 kΩ	1/4 W	5%
R846	315-0511-00			510 Ω	1/4 W	5%
R847	321-0193-00			1 kΩ	1/8 W Prec	1%
R848	321-0146-00			324 Ω	1/8 W Prec	1%
R849	315-0622-00			6.2 kΩ	1/4 W	5%
R850	315-0471-00			470 Ω	1/4 W	5%
R851	315-0332-00			3.3 kΩ	1/4 W	5%
R852	315-0512-00			5.1 kΩ	1/4 W	5%
R853	321-0274-00			6.98 kΩ	1/8 W Prec	1%
R855	321-0280-00			8.06 kΩ	1/8 W Prec	1%
R856	321-0274-00			6.98 kΩ	1/8 W Prec	1%
R858	321-0347-00			40.2 kΩ	1/8 W Prec	1%
R859	321-0260-00			4.99 kΩ	1/8 W Prec	1%
R860	311-0635-00			1 kΩ, Var		
R861	321-0269-00			6.19 kΩ	1/8 W Prec	1%
R863	315-0223-00			22 kΩ	1/4 W	5%
R864	321-0297-00			12.1 kΩ	1/8 W Prec	1%
R866	315-0223-00			22 kΩ	1/4 W	5%
R867	321-0289-00			10 kΩ	1/8 W Prec	1%

A5 READ AMPLIFIER Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors (cont)			
R868	315-0303-00			30 kΩ	1/4 W		5%
R869	315-0124-00			120 kΩ	1/4 W		5%
R871	311-0633-00			5 kΩ, Var			
R872	315-0104-00			100 kΩ	1/4 W		5%
R874	315-0104-00			100 kΩ	1/4 W		5%
R875	311-0633-00			5 kΩ, Var			
R876	315-0124-00			120 kΩ	1/4 W		5%
R877	315-0303-00			30 kΩ	1/4 W		5%
R878	321-0289-00			10 kΩ	1/8 W	Prec	1%
R879	315-0223-00			22 kΩ	1/4 W		5%
R880	321-0297-00			12.1 kΩ	1/8 W	Prec	1%
R881	315-0223-00			22 kΩ	1/4 W		5%
R882	321-0347-00			76.8 kΩ	1/8 W	Prec	1%
R883	321-0274-00			6.98 kΩ	1/8 W	Prec	1%
R885	311-0635-00			1 kΩ, Var			
R886	321-0269-00			6.19 kΩ	1/8 W	Prec	1%
R887	321-0260-00			4.99 kΩ	1/8 W	Prec	1%
R888	321-0274-00			6.98 kΩ	1/8 W	Prec	1%
R889	321-0280-00			8.08 kΩ	1/8 W	Prec	1%
R892	315-0470-00			47 Ω	1/4 W		5%
				Integrated Circuits			
U715	156-0048-00			Linear, replaceable by RCA CA3046			
U730	156-0074-00			Diff video ampl, replaceable by Fairchild μA733C			
U755	156-0107-00			Gate controlled two chan WB ampl, replaceable by Motorola MC1455L			
U794	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P			
U805	156-0020-00			Quad 2-input gate, replaceable by MOT MC824P			
U825	156-0048-00			Linear, replaceable by RCA CA3046			
U852	156-0048-00			Linear, replaceable by RCA CA3046			
U875	156-0048-00			Linear, replaceable by RCA CA3046			

A6 MODULATOR Circuit Board Assembly

	*670-0645-00			Complete Board			
				Capacitors			
Tolerance ±20% unless otherwise indicated.							
C906	290-0158-00			50 μF	Elect.	25 V	+75%—15%
C910	281-0632-00			35 pF	Cer	500 V	1%
C912	281-0111-00			2-27 pF, Var	Air		
C915	283-0059-00			1 μF	Cer	25 V	+80%—20%
C920	281-0503-00			8 pF	Cer	500 V	±0.5 pF

A6 MODULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Capacitors (cont)			
C922	283-0003-00			0.01 μF	Cer	150 V	
C932	283-0003-00			0.01 μF	Cer	150 V	
C935	283-0003-00			0.01 μF	Cer	150 V	
C937	283-0144-00			33 pF	Cer	500 V	1%
C938	281-0575-00			39 pF	Cer	500 V	1%
C940	283-0059-00			1 μF	Cer	25 V	+80%—20%
C942	283-0059-00			1 μF	Cer	25 V	+80%—20%
C1020	283-0004-00			0.02 μF	Cer	150 V	
C1022	283-0129-00			0.56 μF	Cer	100 V	
C1024	290-0194-00			10 μF	Elect.	100 V	
				Inductors			
L937	*114-0289-00			0.15-0.35 μH	Core 276-0568-00		
L1022	108-0224-00			3.9 mH			
				Resistors			
Resistors are fixed, composition, ±10% unless otherwise indicated.							
R901	321-0318-00			20 kΩ	1/8 W	Prec	1%
R902	321-0277-00			7.5 kΩ	1/8 W	Prec	1%
R904	315-0101-00			100 Ω	1/4 W		5%
R906	315-0512-00			5.1 kΩ	1/4 W		5%
R910	315-0102-00			1 kΩ	1/4 W		5%
R912	315-0911-00			910 Ω	1/4 W		5%
R913	321-0077-00			61.9 Ω	1/8 W	Prec	1%
R915	311-0496-00			2.5 kΩ, Var			
R916	315-0432-00			4.3 kΩ	1/4 W		5%
R920	315-0102-00			1 kΩ	1/4 W		5%
R922	315-0222-00			2.2 kΩ	1/4 W		5%
R923	315-0512-00			5.1 k	1/4 W		5%
R930	315-0102-00			1 k	1/4 W		5%
R932	315-0471-00			470 Ω	1/4 W		5%
R934	315-0152-00			1.5 kΩ	1/4 W		5%
R935	315-0123-00			12 kΩ	1/4 W		5%
R940	315-0101-00			100 Ω	1/4 W		5%
R942	315-0101-00			100 Ω	1/4 W		5%
R1026	308-0290-00			8 Ω	5 W	WW	5%
				Transformer			
T912	*120-0624-00			Modulator			

A6 MODULATOR Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Integrated Circuit		
U900	156-0048-00			Linear, replaceable by RCA CA3046		

A7 HV UPPER Circuit Board Assembly

	*670-0644-00			Complete Board		
				Capacitors		
Tolerance ±20% unless otherwise indicated.						
C1031	283-0071-00			0.0068 μF	Cer	5000 V
C1032	283-0071-00			0.0068 μF	Cer	5000 V
C1034	283-0071-00			0.0068 μF	Cer	5000 V
C1036	283-0071-00			0.0068 μF	Cer	5000 V
C1038	290-0285-00			4 μF	Elect.	200 V +50%—10%
C1080	283-0021-00			0.001 μF	Cer	5000 V
C1086	283-0071-00			0.0068 μF	Cer	5000 V
				Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.						
R1034	301-0223-00			22 kΩ	½ W	5%
R1038	315-0102-00			1 kΩ	¼ W	5%
R1080	324-0531-00			3.32 MΩ	1 W Prec	1%
R1081	324-0531-00			3.32 MΩ	1 W Prec	1%
R1082	324-0531-00			3.32 MΩ	1 W Prec	1%
R1083	324-0531-00			3.32 MΩ	1 W Prec	1%
R1086	324-0510-00			2 MΩ	1 W Prec	1%
R1088	301-0104-00			100 kΩ	½ W	5%
R1089	315-0104-00			100 kΩ	¼ W	5%

A8 HV LOWER Circuit Board Assembly

	*670-0643-00			Complete Board		
				Bulbs		
DS1075	150-0002-00			Neon NE2		
DS1076	150-0002-00			Neon NE2		
DS1077	150-0002-00			Neon NE2		

A8 HV LOWER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Capacitors		
Tolerance ±20% unless otherwise indicated.						
C1070	283-0071-00			0.0068 μF	Cer	5000 V
C1071	283-0071-00			0.0068 μF	Cer	5000 V
C1077	283-0162-00			0.01 μF	Cer	5000 V +80%—30%
C1078	283-0088-00			1100 pF	Cer	500 V 5%
				Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.						
R1070	301-0333-00			33 kΩ	½ W	5%
R1071	301-0333-00			33 kΩ	½ W	5%
R1072	305-0335-00			3.3 MΩ	2 W	5%
R1073	305-0335-00			3.3 MΩ	2 W	5%
R1074	305-0335-00			3.3 MΩ	2 W	5%
R1075	305-0335-00			3.3 MΩ	2 W	5%
R1076	305-0335-00			3.3 MΩ	2 W	5%
R1077	305-0335-00			3.3 MΩ	2 W	5%
R1078	301-0223-00			22 kΩ	½ W	5%

A9 LV REGULATOR Circuit Card Assembly

*670-0639-00		Complete Card
		Bulb
DS1133	150-0002-00	Neon NE2
		Capacitors
Tolerance ±20% unless otherwise indicated.		
C1008	285-0683-00	0.022 μF PTM 100 V 5%
C1042	283-0067-00	0.001 μF Cer 200 V 10%
C1046	290-0285-00	4 μF Elect. 200 V +50%—10%
C1054	290-0121-00	2 μF Elect. 25 V
C1056	290-0290-00	10 μF Elect. 25 V
C1112	283-0067-00	0.001 μF Cer 200 V 10%
C1120	283-0129-00	0.56 μF Cer 100 V
C1133	283-0129-00	0.56 μF Cer 100 V
C1152	283-0005-00	0.01 μF Cer 250 V
C1184	290-0106-00	10 μF Elect. 15 V

A9 LV REGULATOR Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Capacitors (cont)			
C1192	283-0067-00		0.001 μF	Cer	200 V	10%
C1212	283-0067-00		0.001 μF	Cer	200 V	10%
C1242	283-0003-00		0.01 μF	Cer	150 V	
C1260	283-0080-00		0.022 μF	Cer	25 V	+80%—20%
			Semiconductor Device, Diodes			
CR1005	*152-0107-00		Silicon	Replaceable by 1N647		
CR1006	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1010	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1040	*152-0061-00		Silicon	Tek Spec		
CR1056	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1105	152-0200-00		Rectifier Bridge	MDA 962-5		
CR1110	152-0232-00		Rectifier Bridge assembly			
CR1112	*152-0107-00		Silicon	Replaceable by 1N647		
CR1114	*152-0061-00		Silicon	Tek Spec		
CR1115	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1121	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1141	*152-0061-00		Silicon	Tek Spec		
CR1144	*152-0061-00		Silicon	Tek Spec		
CR1145	*152-0061-00		Silicon	Tek Spec		
CR1150	152-0200-00		Rectifier Bridge	MDA 962-5		
CR1151	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1152	*152-0061-00		Silicon	Tek Spec		
CR1159	*152-0185-00		Silicon	Replaceable by 1N4152		
CR1160	*152-0061-00		Silicon	Tek Spec		
CR1161	152-0333-00		Silicon	High speed and conductance		
CR1162	152-0333-00		Silicon	High speed and conductance		
CR1163	152-0333-00		Silicon	High speed and conductance		
CR1170A,B,C,D(4)	152-0198-00		Silicon	MR 1032A, 200 V PIV		
CR1180	152-0333-00		Silicon	High speed and conductance		
CR1181	152-0333-00		Silicon	High speed and conductance		
CR1182	152-0333-00		Silicon	High speed and conductance		
CR1190A,B(2)	152-0198-00		Silicon	MR 1032A, 200 V PIV		
CR1201	152-0333-00		Silicon	High speed and conductance		
CR1202	152-0333-00		Silicon	High speed and conductance		
CR1203	152-0333-00		Silicon	High speed and conductance		
CR1221	152-0333-00		Silicon	High speed and conductance		
CR1222	152-0333-00		Silicon	High speed and conductance		
CR1223	152-0333-00		Silicon	High speed and conductance		
CR1231	152-0333-00		Silicon	High speed and conductance		
CR1232	152-0333-00		Silicon	High speed and conductance		

A9 LV REGULATOR Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
		Semiconductor Device, Diodes (cont)		
CR1233	152-0333-00			Silicon High speed and conductance
CR1257	*152-0185-00			Silicon Replaceable by 1N4152
CR1258	*152-0185-00			Silicon Replaceable by 1N4152
CR1263	152-0333-00			Silicon High speed and conductance
CR1264	152-0333-00			Silicon High speed and conductance
VR1122	152-0147-00			Zener 1N971B 400 mW, 27 V, 5%
VR1143	152-0289-00			Zener 1N991B 400 mW, 180 V, 5%
VR1171	152-0147-00			Zener 1N971B 400 mW, 27 V, 5%
VR1175	152-0212-00			Zener 1N936 500 mW, 9 V, 5% TC
VR1215	152-0306-00			Zener 1N960B 400 mW, 9.1 V, 5%
VR1255	152-0306-00			Zener 1N960B 400 mW, 9.1 V, 5%
VR1262	152-0149-00			Zener 1N961B 400 mW, 10 V, 5%
		Fuse		
F1107	159-0033-00			1/8 A 8 AG Fast-Blo
		Transistors		
Q1010	151-1005-00			Silicon FET N channel, junction type
Q1015	151-0208-00			Silicon PNP TO-5 2N4036
Q1018	*151-0121-00	B100000	B100489	Silicon NPN TO-5 Selected from 2N3118
Q1018	*151-0124-00	B100490		Silicon NPN TO-5 Selected from 2N3119
Q1040	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q1050	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q1060	151-0232-00			Silicon NPN TO-78 Dual
Q1110	151-0232-00			Silicon NPN TO-78 Dual
Q1112	151-0232-00			Silicon NPN TO-78 Dual
Q1120	151-0232-00			Silicon NPN TO-78 Dual
Q1140	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q1150	151-0232-00			Silicon NPN TO-78 Dual
Q1152	151-0190-00			Silicon NPN TO-92 2N3904
Q1160	*151-0150-00			Silicon NPN TO-5 Selected from 2N3440
Q1180	*151-0103-00			Silicon NPN TO-5 Replaceable by 2N2219
Q1190	151-0232-00			Silicon NPN TO-78 Dual
Q1200	151-0188-00			Silicon PNP TO-92 2N3906
Q1202	*151-0103-00			Silicon NPN TO-5 Replaceable by 2N2219
Q1210	151-0232-00			Silicon NPN TO-78 Dual
Q1220	151-0188-00			Silicon PNP TO-92 2N3906
Q1222	*151-0103-00			Silicon NPN TO-5 Replaceable by 2N2219
Q1230	*151-0261-00			Silicon PNP TO-78 Dual, Tek Spec
Q1240	151-0190-00			Silicon NPN TO-92 2N3904
Q1250	151-0232-00			Silicon NPN TO-78 Dual
Q1260	151-0208-00			Silicon PNP TO-5 2N4036

A9 LV REGULATOR Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
				Resistors		
Resistors are fixed, composition, ±10% unless otherwise indicated.						
R1001	311-0905-00			100 kΩ, Var		
R1002	321-0440-00			374 kΩ	1/8 W	Prec 1%
R1004	323-0481-00			1 MΩ	1/2 W	Prec 1%
R1005	315-0104-00			100 kΩ	1/4 W	5%
R1006	315-0105-00			1 MΩ	1/4 W	5%
R1008	315-0103-00			10 kΩ	1/4 W	5%
R1010	301-0204-00			200 kΩ	1/2 W	5%
R1012	315-0102-00			1 kΩ	1/4 W	5%
R1014	315-0302-00			3 kΩ	1/4 W	5%
R1016	315-0102-00			1 kΩ	1/4 W	5%
R1018	315-0152-00			1.5 kΩ	1/4 W	5%
R1042	315-0101-00			100 Ω	1/4 W	5%
R1044	315-0104-00			100 kΩ	1/4 W	5%
R1046	323-0403-00			154 kΩ	1/2 W	Prec 1%
R1050	323-0389-00			110 kΩ	1/2 W	Prec 1%
R1051	321-0280-00			8.06 kΩ	1/8 W	Prec 1%
R1052	315-0103-00			10 kΩ	1/4 W	5%
R1054	321-0307-00			15.4 kΩ	1/8 W	Prec 1%
R1056	315-0244-00			240 kΩ	1/4 W	5%
R1057	315-0303-00			30 kΩ	1/4 W	5%
R1061	321-0380-00			88.7 kΩ	1/8 W	Prec 1%
R1065	323-0399-00			140 kΩ	1/2 W	Prec 1%
R1066	311-0868-00			24 kΩ, Var		
R1110	303-0753-00			75 kΩ	1 W	5%
R1112	315-0102-00			1 kΩ	1/4 W	5%
R1115	301-0154-00			150 kΩ	1/2 W	5%
R1117	305-0433-00			43 kΩ	2 W	5%
R1120	321-0301-01			13.3 kΩ	1/8 W	Prec 1/2%
R1121	315-0221-00			220 Ω	1/4 W	5%
R1122	301-0104-00			100 kΩ	1/2 W	5%
R1124	321-1289-01			10.1 kΩ	1/8 W	Prec 1/2%
R1125	321-0261-00			5.11 kΩ	1/8 W	Prec 1%
R1131	315-0221-00			220 Ω	1/4 W	5%
R1132	321-0301-01			13.3 kΩ	1/8 W	Prec 1/2%
R1133	316-0225-00			2.2 MΩ	1/4 W	
R1134	323-0393-00			121 kΩ	1/2 W	Prec 1%
R1140	315-0101-00			100 Ω	1/4 W	5%
R1142	315-0104-00			100 kΩ	1/4 W	5%
R1144	315-0331-00			330 Ω	1/4 W	5%
R1149	307-0104-00			3.3 Ω	1/4 W	5%

A9 LV REGULATOR Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
			Resistors (cont)			
R1151	301-0334-00		330 kΩ	1/2 W		5%
R1152	315-0102-00		1 kΩ	1/4 W		5%
R1153	301-0224-00		220 kΩ	1/2 W		5%
R1154	315-0432-00		4.3 kΩ	1/4 W		5%
R1156	315-0362-00		3.6 kΩ	1/4 W		5%
R1158	321-0267-00		5.9 kΩ	1/8 W	Prec	1%
R1159	321-0302-00		13.7 kΩ	1/8 W	Prec	1%
R1161	315-0101-00		100 Ω	1/4 W		5%
R1163	315-0220-00		22 Ω	1/4 W		5%
R1167	325-0054-00		2.2 Ω	1/2 W	Prec	1%
R1171	303-0332-00		3.3 kΩ	1 W		5%
R1173	315-0102-00		1 kΩ	1/4 W		5%
R1175	315-0202-00		2 kΩ	1/4 W		5%
R1176	315-0821-00		820 Ω	1/4 W		5%
R1178	315-0202-00		2 kΩ	1/4 W		5%
R1180	315-0103-00		10 kΩ	1/4 W		5%
R1182	321-0251-00		4.02 kΩ	1/8 W	Prec	1%
R1183	311-0266-00		500 Ω, Var			
R1184	321-0234-00		2.67 kΩ	1/8 W	Prec	1%
R1186	315-0120-00		12 Ω	1/4 W		5%
R1189	308-0224-00		0.3 Ω	2 W	WW	
R1191	315-0202-00		2 kΩ	1/4 W		5%
R1192	315-0331-00		330 Ω	1/4 W		5%
R1193	315-0162-00		1.6 kΩ	1/4 W		5%
R1194	321-0265-00		5.62 kΩ	1/8 W	Prec	1%
R1195	321-0219-00		1.87 kΩ	1/8 W	Prec	1%
R1197	315-0621-00		620 Ω	1/4 W		5%
R1199	315-0152-00		1.5 kΩ	1/4 W		5%
R1202	307-0113-00		5.1 Ω	1/4 W		5%
R1207	308-0244-00		0.3 Ω	2 W	WW	
R1210	315-0272-00		2.7 kΩ	1/4 W		5%
R1212	315-0331-00		330 Ω	1/4 W		5%
R1213	315-0362-00		3.6 kΩ	1/4 W		5%
R1214	315-0752-00		7.5 kΩ	1/4 W		5%
R1215	315-0222-00		2.2 kΩ	1/4 W		5%
R1216	301-0122-00		1.2 kΩ	1/2 W		5%
R1218	321-0306-00		15 kΩ	1/8 W	Prec	1%
R1219	321-0306-00		15 kΩ	1/8 W	Prec	1%
R1221	315-0512-00		5.1 kΩ	1/4 W		5%
R1222	307-0113-00		5.1 Ω	1/4 W		5%
R1227	308-0244-00		0.3 Ω	2 W	WW	
R1230	315-0122-00		1.2 kΩ	1/4 W		5%
R1232	315-0512-00		5.1 kΩ	1/4 W		5%
R1235	321-0259-00		4.87 kΩ	1/8 W	Prec	1%
R1236	321-0213-00		1.62 kΩ	1/8 W	Prec	1%

A9 LV REGULATOR Circuit Card Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Description		
				Resistors (cont)		
R1240	315-0102-00			1 kΩ	1/4 W	5%
R1243	307-0113-00			5.1 Ω	1/4 W	5%
R1248	307-0103-00			2.7 Ω	1/4 W	5%
R1250	301-0561-00			560	1/2 W	5%
R1253	315-0392-00			3.9 k	1/4 W	5%
R1254	315-0113-00			11 kΩ	1/4 W	5%
R1255	315-0222-00			2.2 kΩ	1/4 W	5%
R1256	301-0103-00			10 kΩ	1/2 W	5%
R1257	303-0104-00			100 kΩ	1 W	5%
R1258	321-0306-00			15 kΩ	1/8 W Prec	1%
R1259	321-0356-00			49.9 kΩ	1/8 W Prec	1%
R1260	315-0331-00			330 Ω	1/4 W	5%
R1263	301-0512-00			5.1 kΩ	1/2 W	5%
R1267	308-0365-00			1.5 Ω	3 W WW	5%
				Integrated Circuit		
U1170	156-0049-00			Op. ampl, replaceable by Fairchild μA741C		

SECTION 8

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

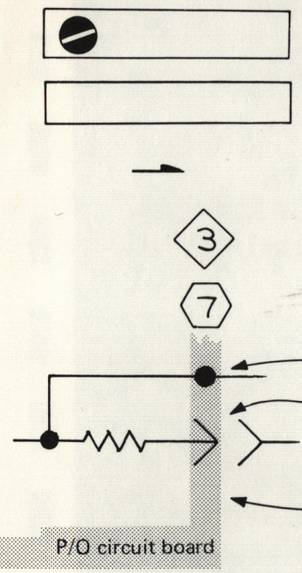
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF).
Values less than one are in microfarads (μF).
Resistors = Ohms (Ω)

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:



External Screwdriver adjustment.

External control or connector.

Clockwise control rotation in direction of arrow.

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.

Connection soldered to circuit board.

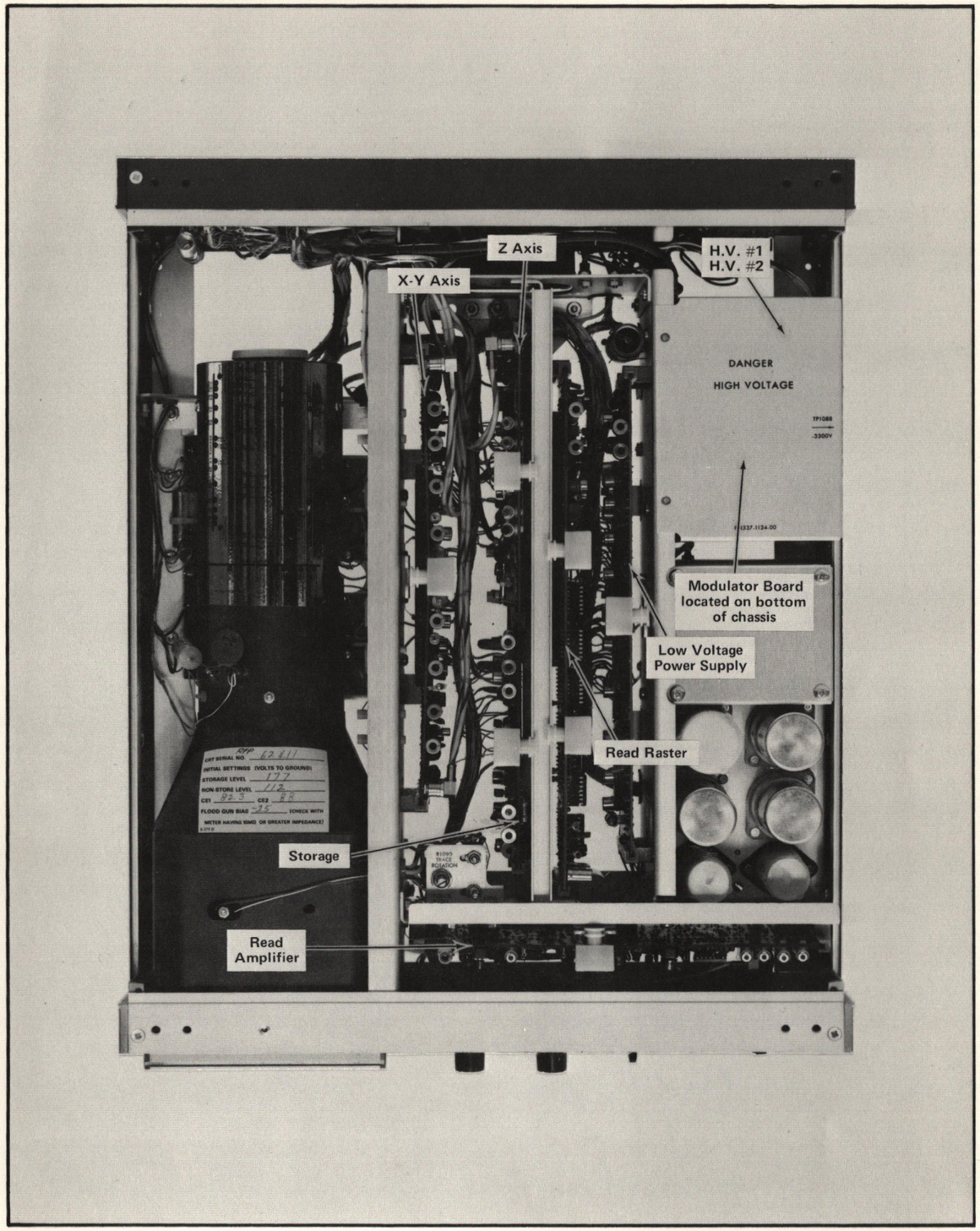
Connection made to circuit board with interconnecting pin.

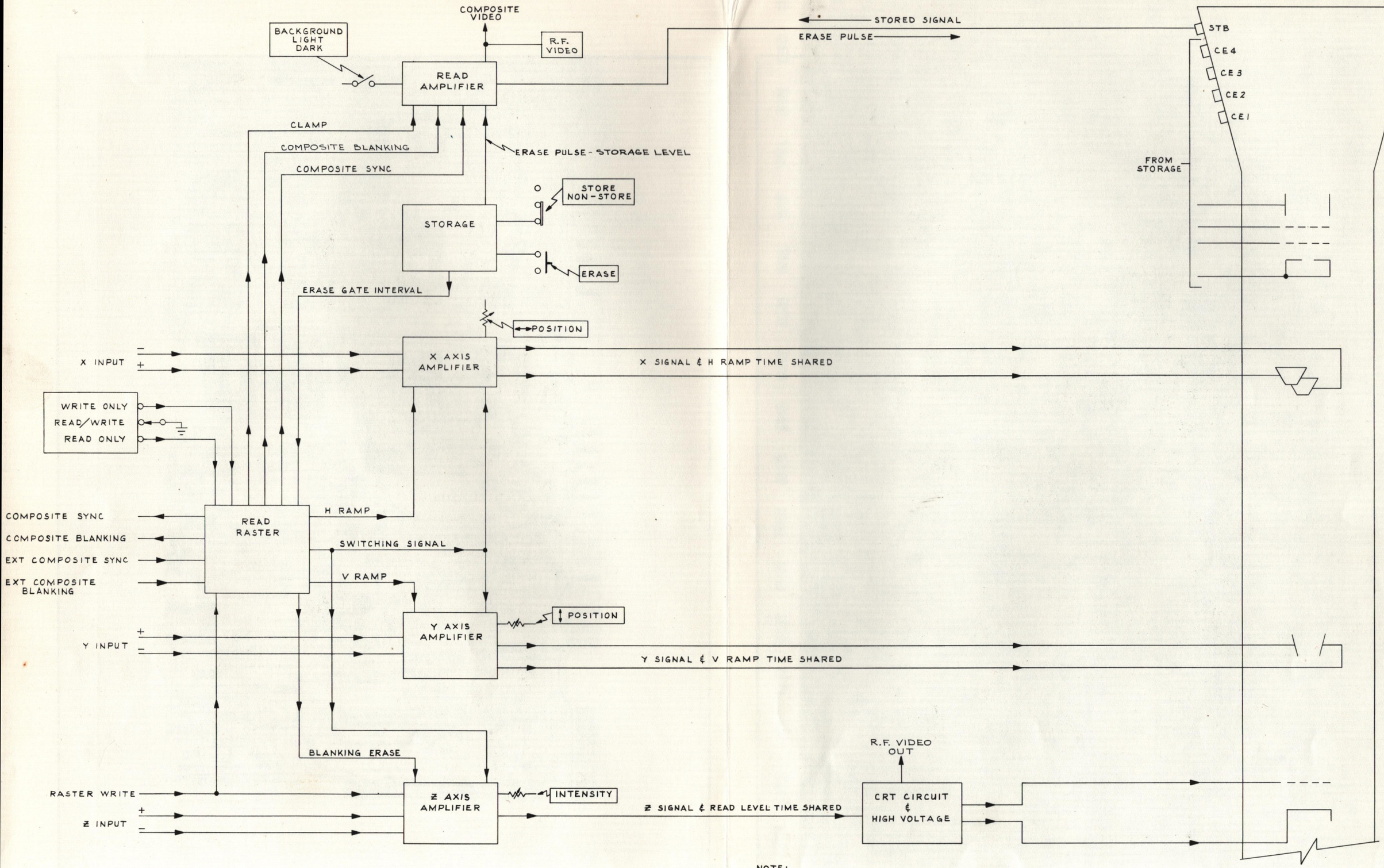
Blue tint encloses components located on circuit board.

The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

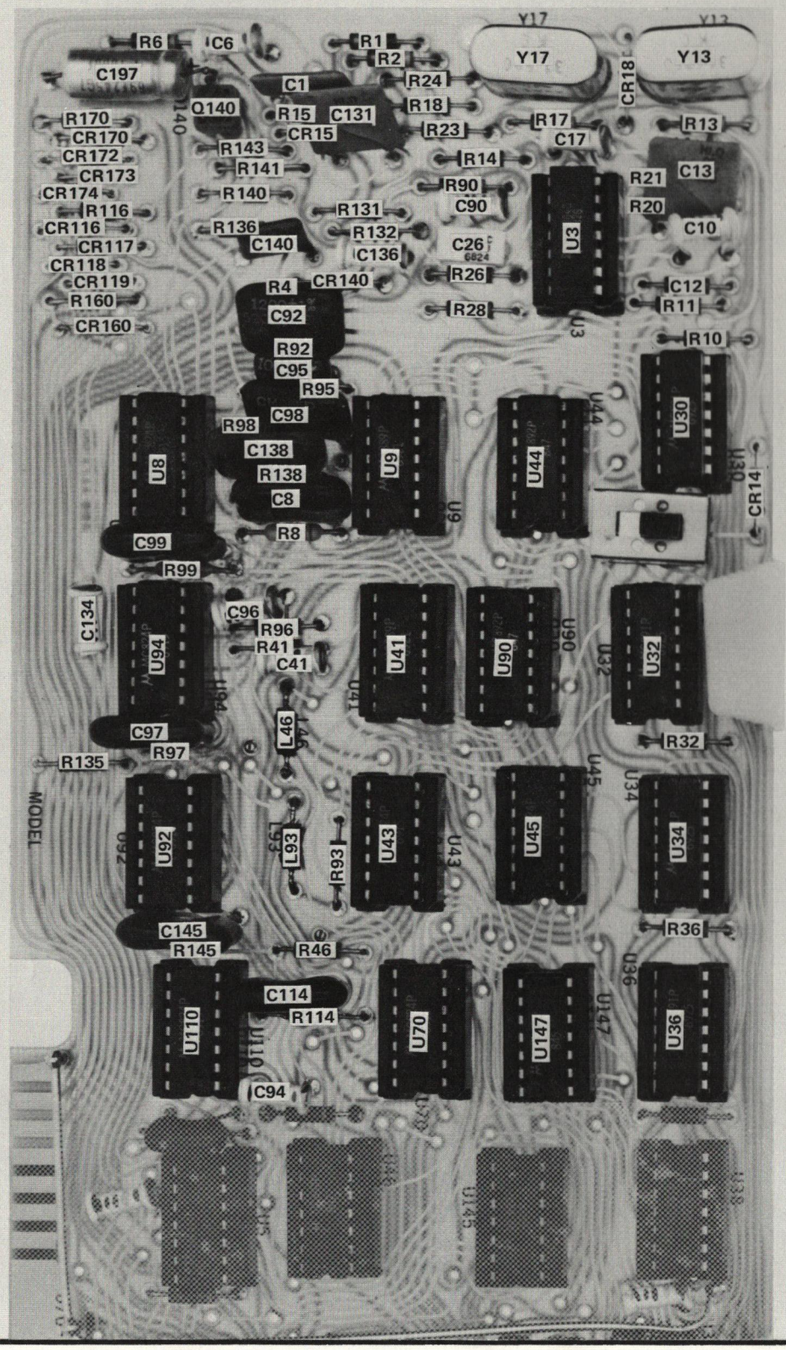
A	Assembly, separable or repairable (circuit board, etc.)
AT	Attenuator, fixed or variable
B	Motor
BT	Battery
C	Capacitor, fixed or variable
CR	Diode, signal or rectifier
DL	Delay line
DS	Indicating device (lamp)
F	Fuse
FL	Filter
H	Heat dissipating device (heat sink, heat radiator, etc.)
HR	Heater
J	Connector, stationary portion
K	Relay
L	Inductor, fixed or variable
LR	Inductor/resistor combination
M	Meter
Q	Transistor or silicon-controlled rectifier
P	Connector, movable portion
R	Resistor, fixed or variable
RT	Thermistor
S	Switch
T	Transformer
TP	Test point
U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
V	Electron tube
VR	Voltage regulator (zener diode, etc.)
Y	Crystal

	Assembly Name
A-1	READ RASTER Circuit Card Assembly
A-2	Z AXIS AMPLIFIER Circuit Card Assembly
A-3	X-Y AMPLIFIER Circuit Card Assembly
A-4	STORAGE Circuit Card Assembly
A-5	READ AMPLIFIER Circuit Card Assembly
A-6	MODULATOR Circuit Board Assembly
A-7	H.V. UPPER Circuit Board Assembly
A-8	H.V. LOWER Circuit Board Assembly
A-9	L.V. REGULATOR Circuit Card Assembly





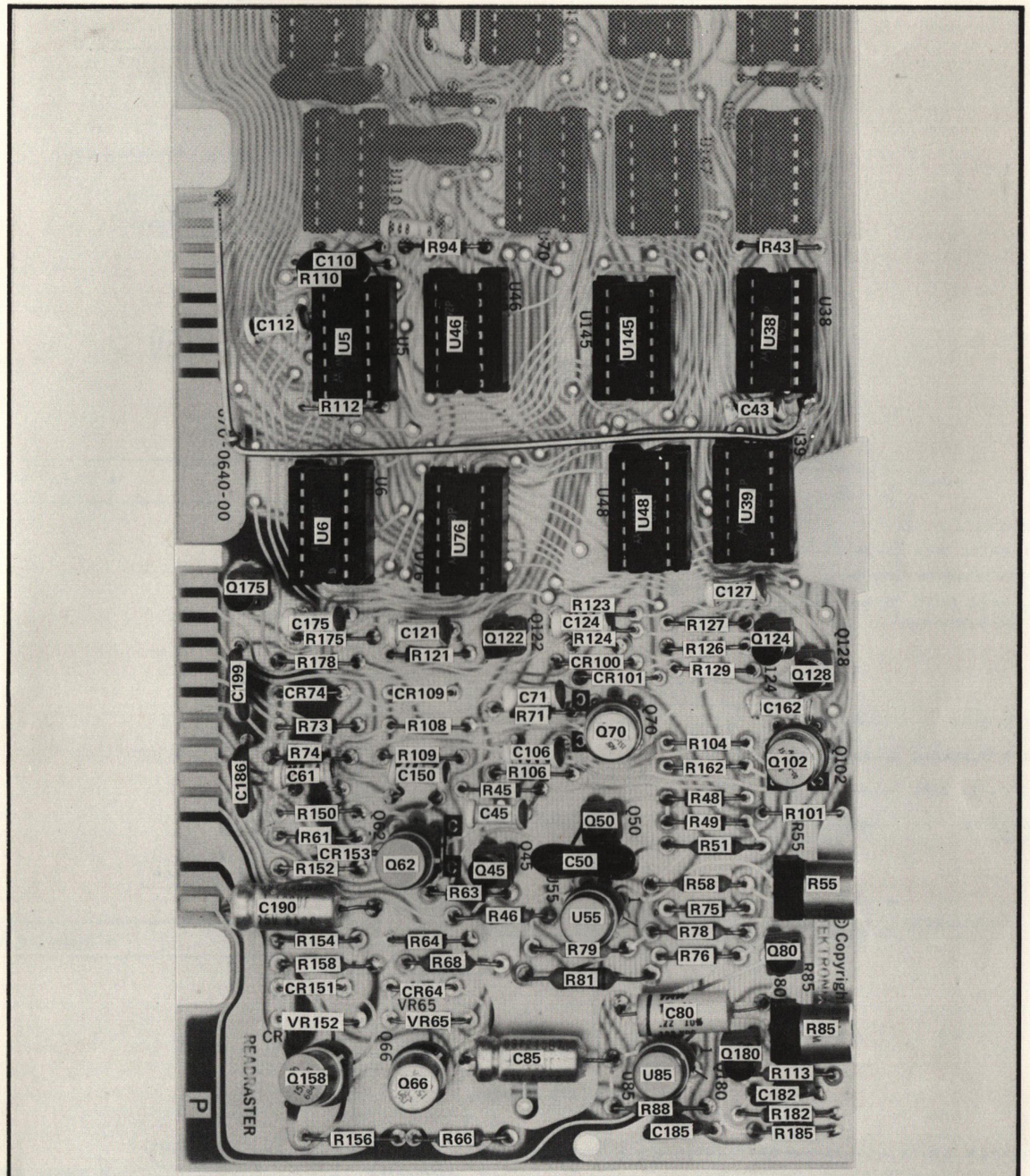
NOTE:
1. REFER TO REMOTE PROGRAM TABLES IN SECTION 2 FOR FUNCTION OF PROGRAM LINES.



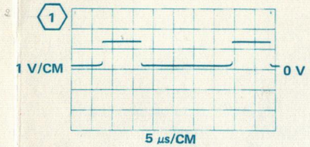
R95, R97
R98, R145

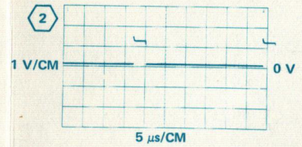
On back of board

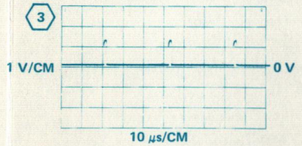
A

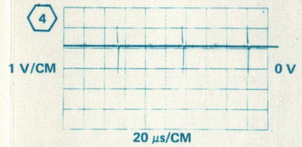


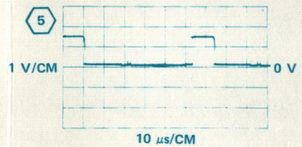
A

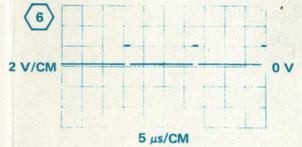


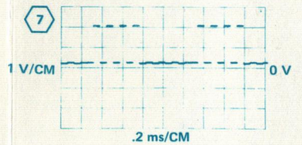


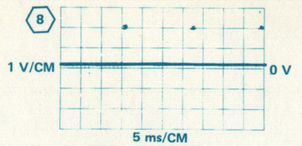


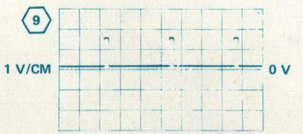


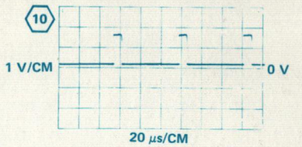


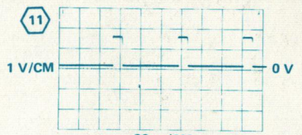


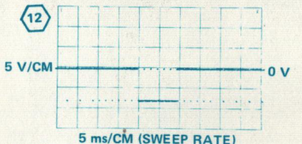


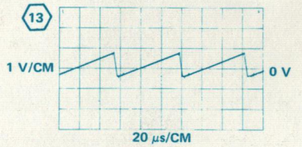


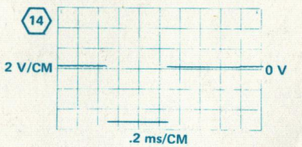


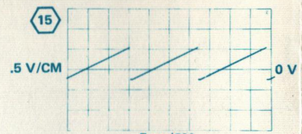


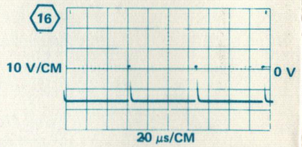


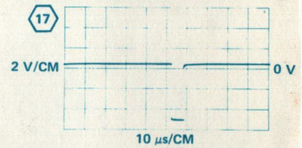


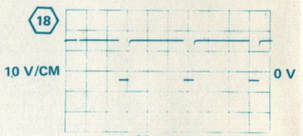


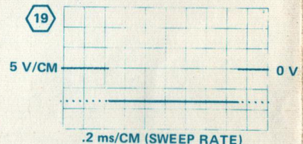


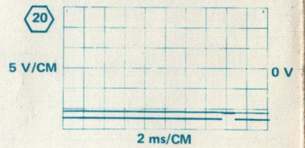


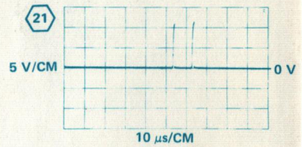








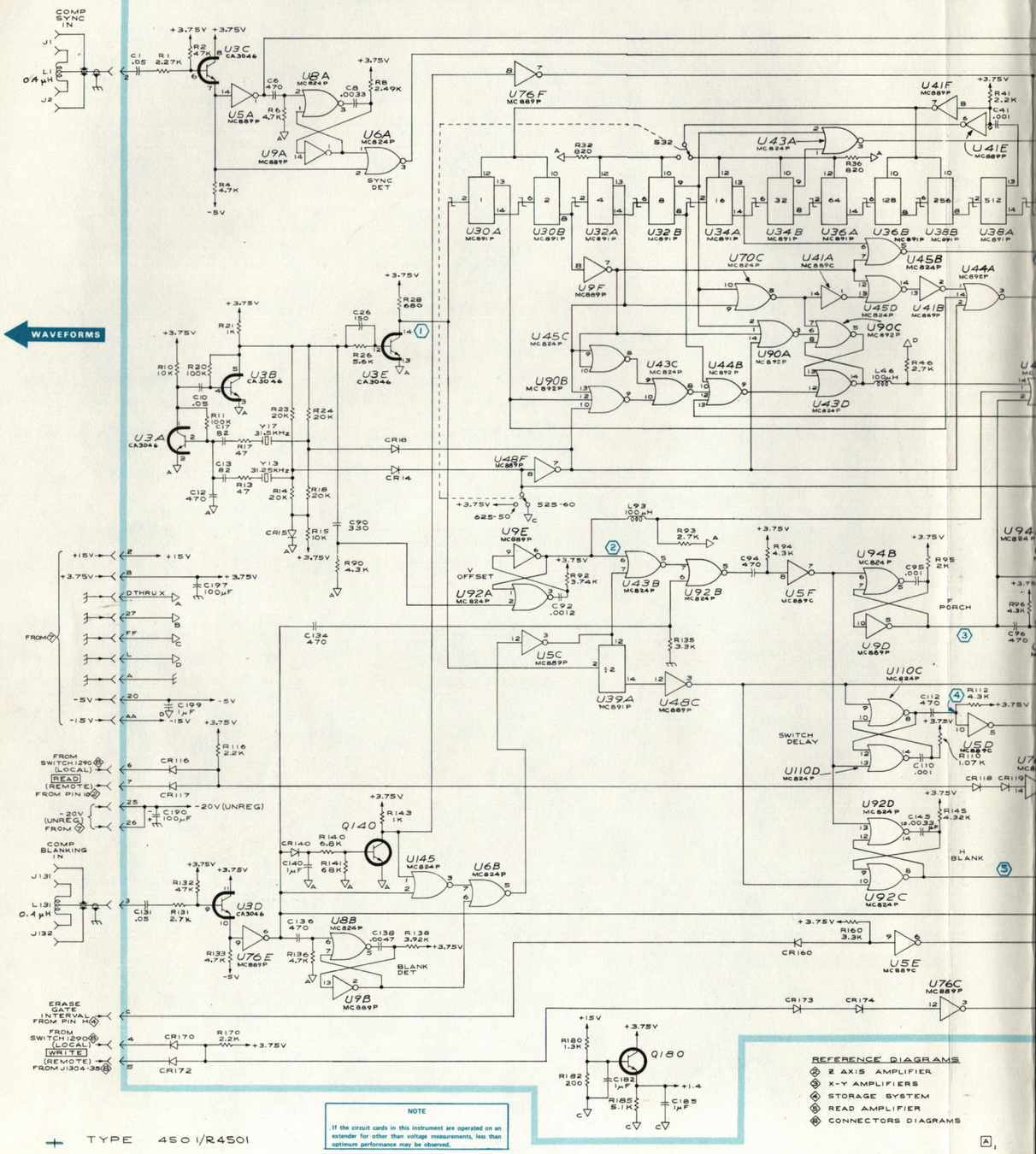




WAVEFORM CONDITIONS

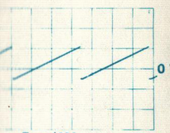
Type 4501		Test Oscilloscope	
MODE	WRITE AND READ	Trigger	+EXT (Composite Blanking)
STORE/NON-STORE	NON-STORE		
BACKGROUND	DARK		AC
PROGRAM	LOCAL	10X Probe	DC Coupled

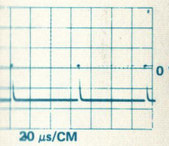
WAVEFORMS

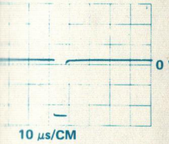


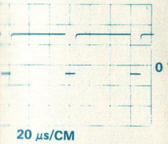
NOTE

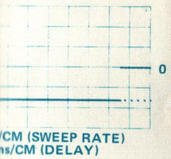
If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.

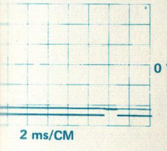

0 V
5 ms/CM

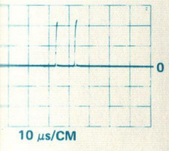

0 V
20 µs/CM

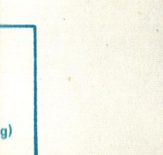

0 V
10 µs/CM


0 V
20 µs/CM

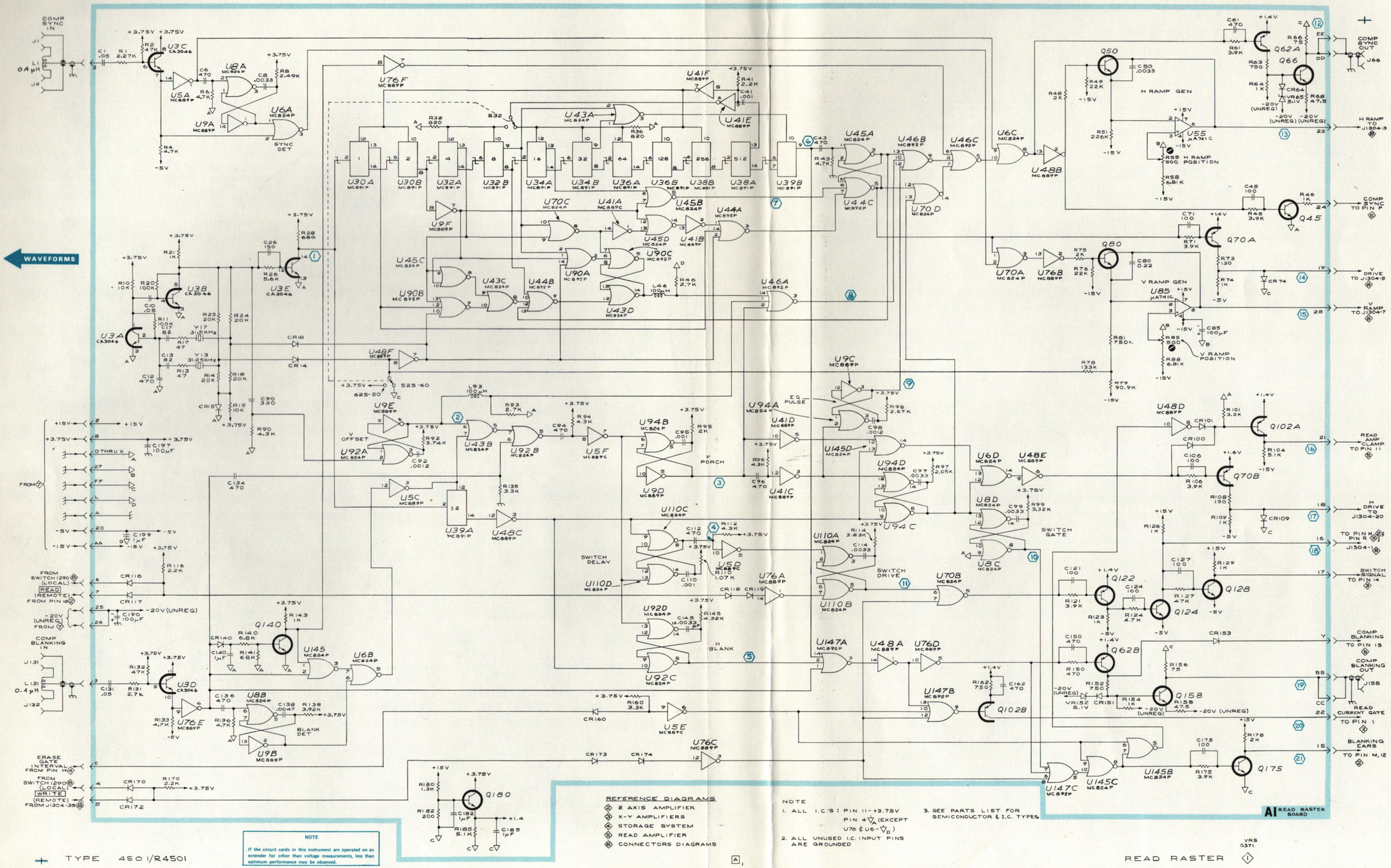

0 V
/CM (SWEEP RATE)
ns/CM (DELAY)

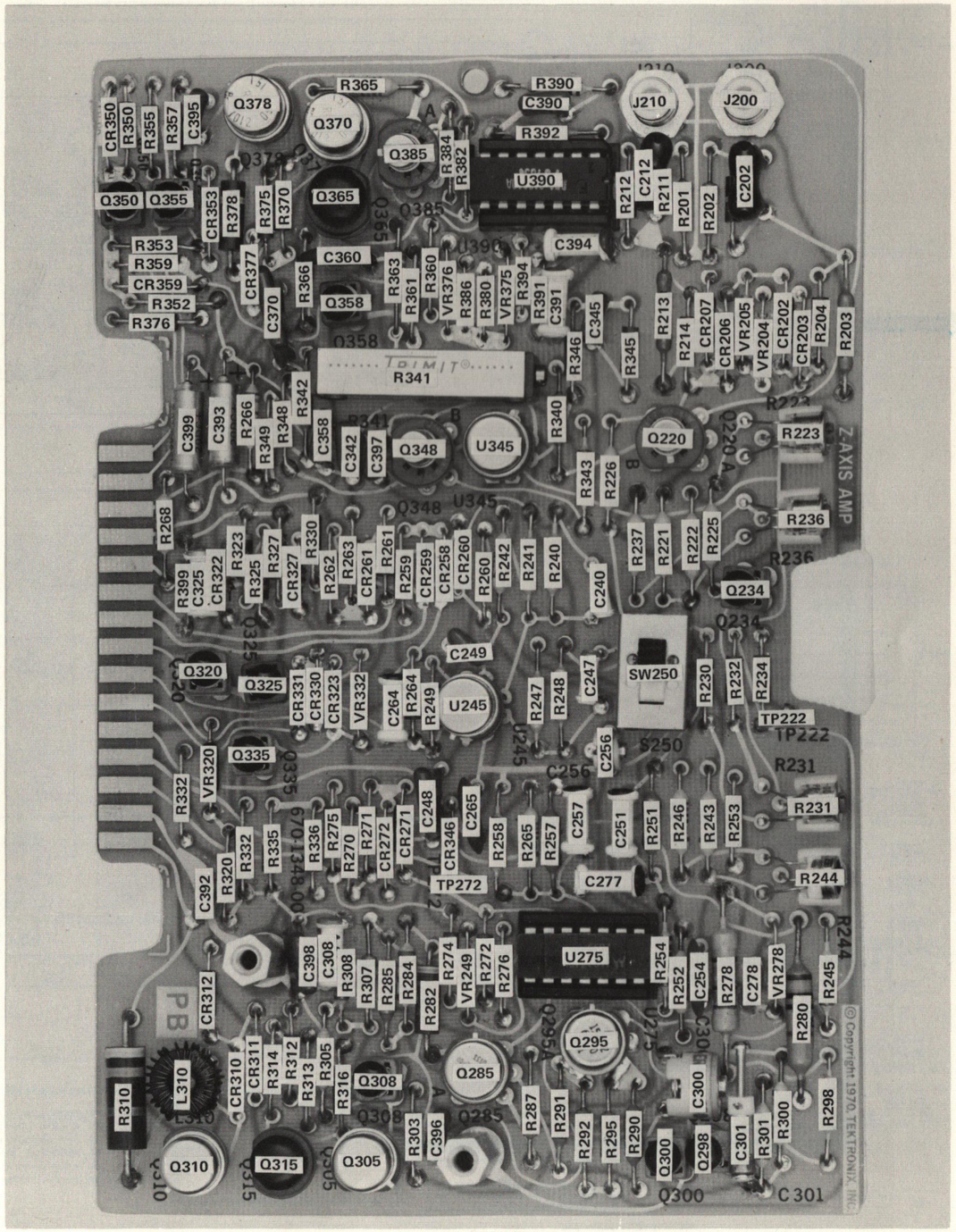

0 V
2 ms/CM


0 V


0 V
10 µs/CM

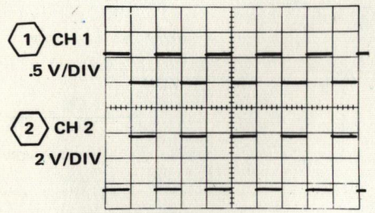
WAVEFORMS

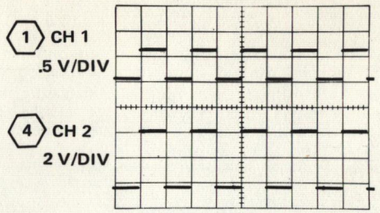

COMP SYNC IN
U3C CA3046
U5A MC889P
U8A MC824P
U9A MC889P
SYNC DET
U6A MC824P
U76F MC889P
U41F MC889P
U41E MC889P
U43A MC824P
S32
U30A MC891P
U30B MC891P
U32A MC891P
U32B MC891P
U34A MC891P
U34B MC891P
U36A MC891P
U36B MC891P
U38B MC891P
U38A MC891P
U39B MC891P
U45A MC824P
U46B MC892P
U46C MC892P
U6C MC824P
U48B MC889P
U44C MC892P
U70D MC824P
U9F MC889P
U70C MC824P
U41A MC889P
U45B MC824P
U44A MC892P
U45D MC824P
U41B MC889P
U45C MC824P
U43C MC824P
U44B MC892P
U90A MC892P
U90C MC892P
U90B MC892P
U43D MC824P
U46A MC892P
U48F MC889P
U9E MC889P
U92A MC824P
U43B MC824P
U92B MC824P
U5F MC889P
U5C MC889P
U39A MC891P
U48C MC889P
U94B MC824P
U9D MC889P
U110C MC824P
U5D MC889P
U110D MC824P
U92D MC824P
U92C MC824P
U9C MC889P
U94A MC824P
U41D MC889P
U145D MC824P
U41C MC889P
U94D MC824P
U94C
U110A MC824P
U110B MC824P
U147A MC892P
U147B MC892P
U147C MC892P
U5E MC889P
U76A MC889P
U76C MC889P
U70B MC824P
U6D MC824P
U48E MC889P
U8D MC824P
U8C MC824P
SWITCH GATE
SWITCH DRIVE
H BLANK
F PORCH
EQ PULSE
V OFFSET
BLANK DET
U3A CA3046
U3B CA3046
U3E CA3046
U3D CA3046
U8B MC824P
U9B MC889P
U76E MC889P
U145B MC824P
U145C MC824P
U48D MC889P
U70A MC824P
U76B MC889P
U48A MC889P
U76D MC889P
Q140
U145 MC824P
U6B MC824P
Q180
Q50
H RAMP GEN
U55 µA741C
Q62A
Q66
Q45
Q80
V RAMP GEN
U85 µA741C
Q70A
Q102A
Q70B
Q122
Q124
Q128
Q62B
Q158
Q102B
Q175
H RAMP POSITION
V RAMP POSITION
SWITCH SIGNAL
COMP SYNC OUT
COMP SYNC TO PIN P
V DRIVE TO J1304-5
V RAMP TO J1304-7
H DRIVE TO J1304-10
TO PIN H PIN R J1304-18
READ AMP CLAMP TO PIN 11
COMP BLANKING TO PIN 15
COMP BLANKING OUT
READ CURRENT GATE TO PIN 1
BLANKING EARS TO PIN M, 12
FROM SWITCH 1290 (LOCAL) READ (REMOTE) FROM PIN 10
FROM SWITCH 1290 (LOCAL) WRITE (REMOTE) FROM J1304-35
ERASE GATE INTERVAL FROM PIN H
COMP BLANKING IN
J131
J132
L131 0.4 µH
L132 0.4 µH
+15V
+3.75V
-5V
-15V
-20V (UNREG)
+1.4V
+1.6V
+3.75V
525-60
625-50
D THRU X
FROM
TO
REFERENCE DIAGRAMS
Z AXIS AMPLIFIER
X-Y AMPLIFIERS
STORAGE SYSTEM
READ AMPLIFIER
CONNECTORS DIAGRAMS
NOTE
If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.
NOTE
1. ALL I.C.'S: PIN 11 - +3.75V
PIN 4 (EXCEPT U76 & U6 -)
2. ALL UNUSED I.C. INPUT PINS ARE GROUNDED
3. SEE PARTS LIST FOR SEMICONDUCTOR & I.C. TYPES
AI READ RASTER BOARD
TYPE 4501/R4501
READ RASTER
SN B100000 -UP
VRS 0371

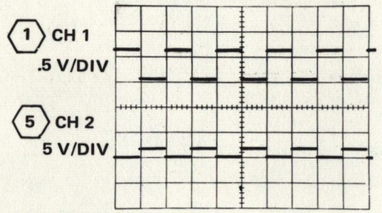


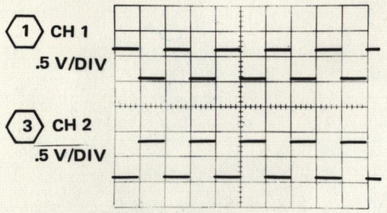
Z AXIS AMPLIFIER Circuit Card Assembly

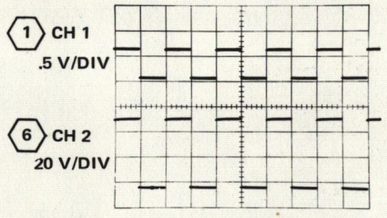
A











VOLTAGE AND WAVEFORM CONDITIONS

All waveforms unless noted otherwise.

Test Oscilloscope

ALTernate trace mode selected

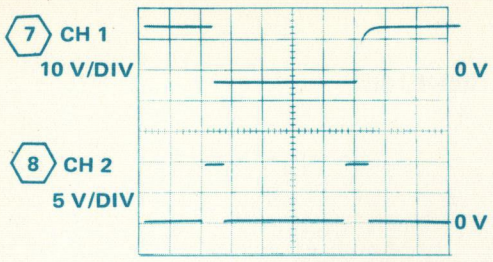
Trigger	+INT AC coupled
10X probes	DC coupled

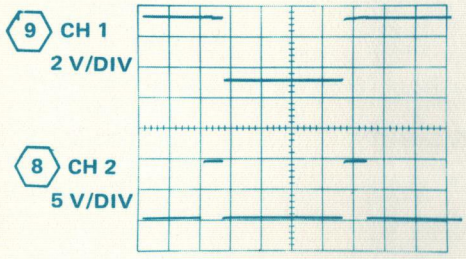
Type 4501

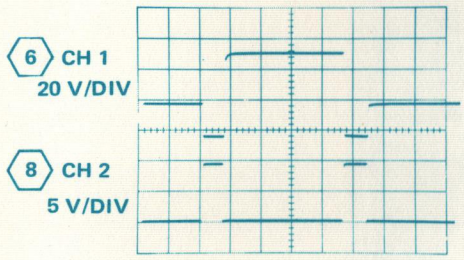
PROGRAM	LOCAL
INTENSITY	fully CW

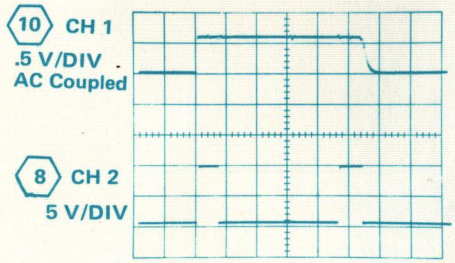
Group 1 Waveforms

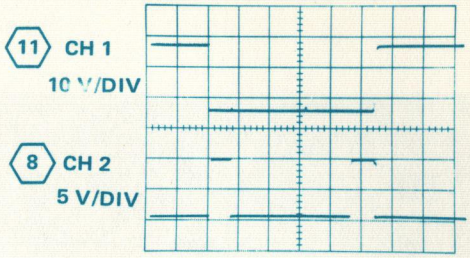
1. Type 4501 set to Limiting and WRITE ONLY.
2. A +1 V, 1 kHz square wave fed to the 4501 +Z input (J200).
3. Test oscilloscope Time/Div set to .5 ms.

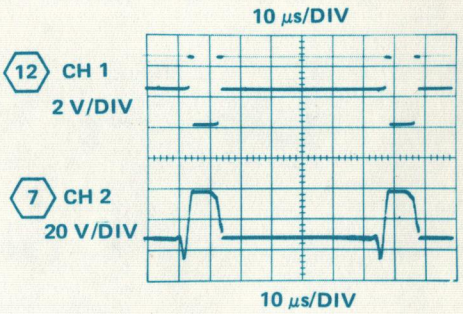


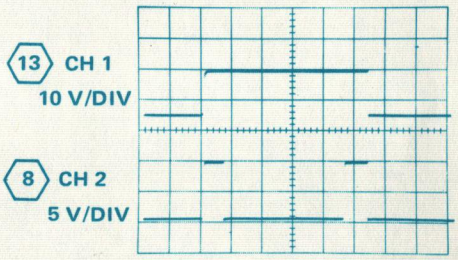












VOLTAGE AND WAVEFORM CONDITIONS

All waveforms unless noted otherwise.

Test Oscilloscope

ALTernate trace mode selected

Trigger — +INT, AC coupled, DC coupled

10X probes

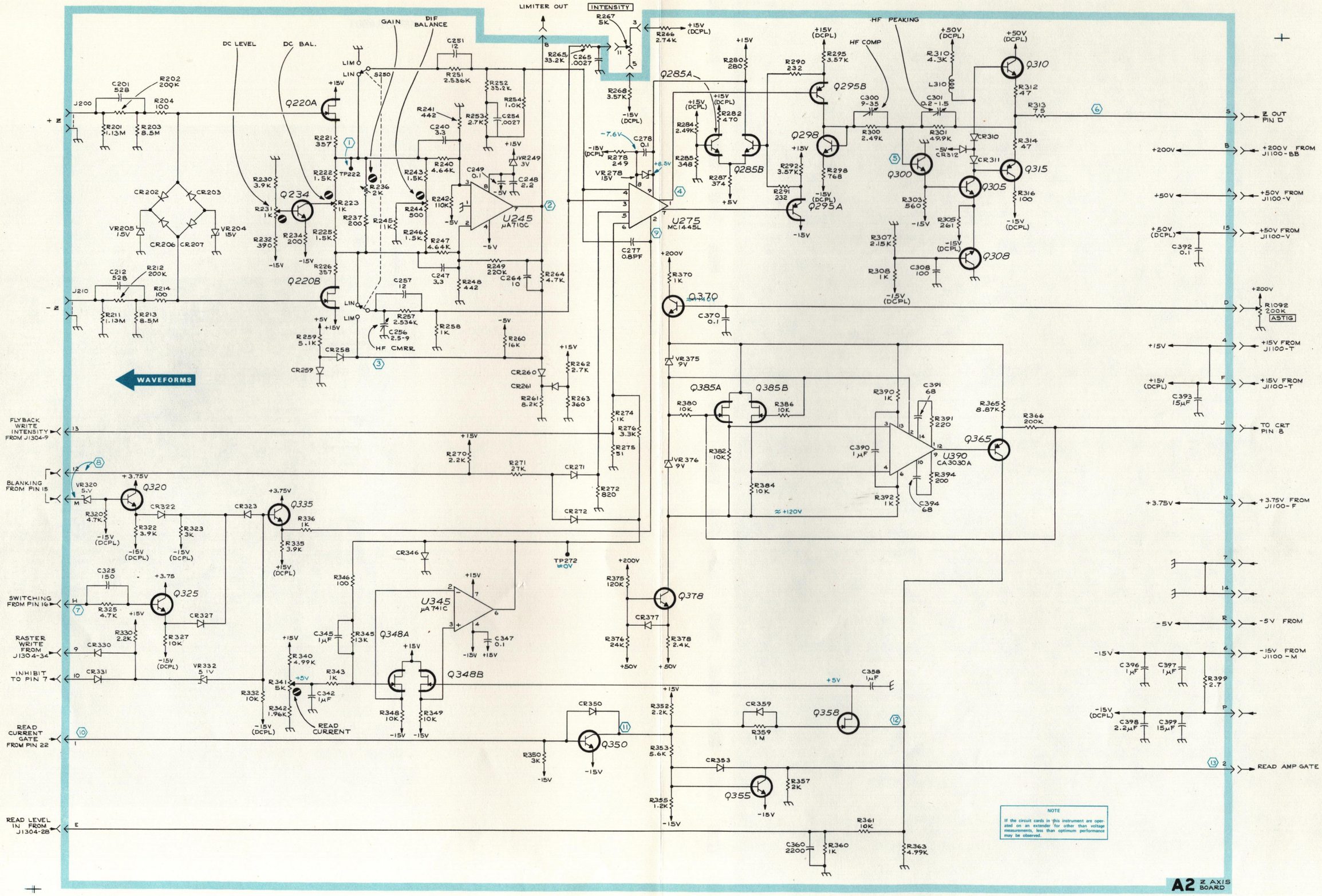
Type 4501

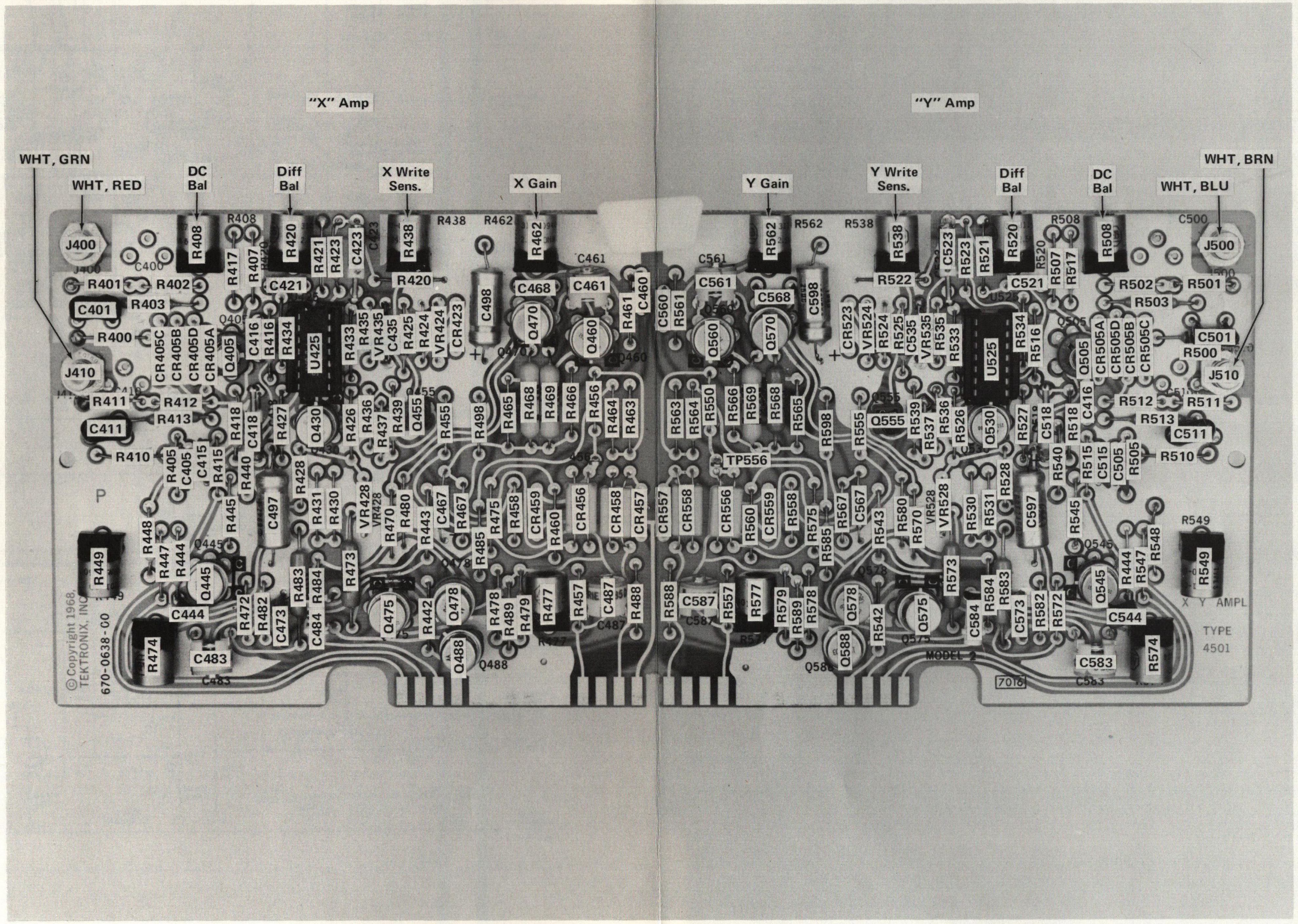
PROGRAM — LOCAL

INTENSITY — fully CW

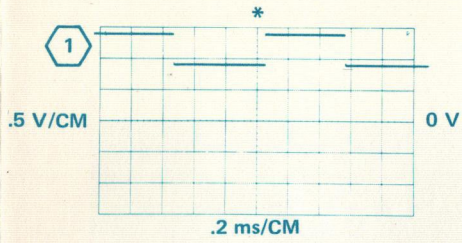
Group 2 Waveforms

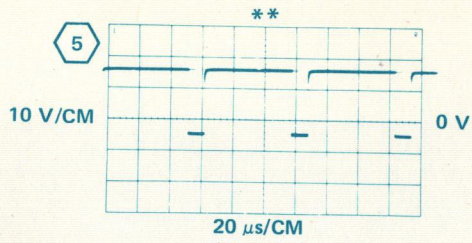
1. Type 4501 set to Linear, and WRITE AND READ.
2. Test oscilloscope Time/Div set to 2 μs unless noted otherwise.

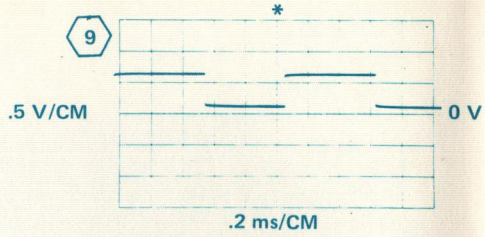

LIMITER OUT
INTENSITY
GAIN
DIF BALANCE
DC LEVEL
DC BAL.
HF PEAKING
HF COMP
HF CMRR
READ CURRENT
WAVEFORMS
U245 μA710C
U275 MC1445L
U345 μA741C
U390 CA3030A
Q220A
Q220B
Q234
Q285A
Q285B
Q295A
Q295B
Q298
Q300
Q305
Q308
Q310
Q315
Q320
Q325
Q335
Q345
Q348A
Q348B
Q350
Q355
Q358
Q365
Q370
Q375
Q378
Q385A
Q385B
+IN
-IN
LIMO
LIN
S250
TP222
TP272
≈0V
≈+120V
-7.6V
+8.5V
FLYBACK WRITE INTENSITY FROM J1304-9
BLANKING FROM PIN 15
SWITCHING FROM PIN 16
RASTER WRITE FROM J1304-34
INHIBIT TO PIN 7
READ CURRENT GATE FROM PIN 22
READ LEVEL IN FROM J1304-28
Z OUT PIN D
+200V FROM J1100-BB
+50V FROM J1100-V
+50V FROM J1100-V
+15V FROM J1100-T
+15V FROM J1100-T
TO CRT PIN 8
+3.75V FROM J1100-F
-5V FROM
-15V FROM J1100-M
READ AMP GATE
R1092 200K ASTIG
NOTE
If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.
A2 Z AXIS BOARD

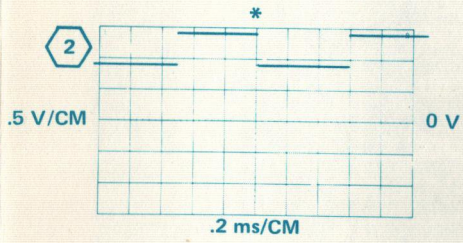

"X" Amp
"Y" Amp
WHT, GRN
WHT, RED
DC Bal
Diff Bal
X Write Sens.
X Gain
Y Gain
Y Write Sens.
Diff Bal
DC Bal
WHT, BLU
WHT, BRN
© Copyright 1968, TEKTRONIX, INC.
670-0638-00
X Y AMPL
TYPE 4501

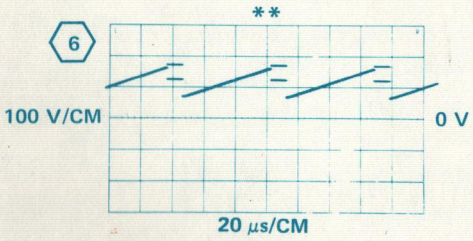
A

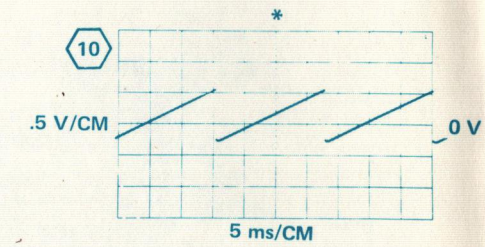


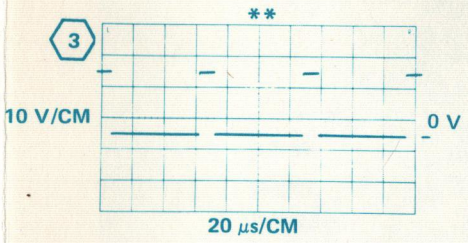


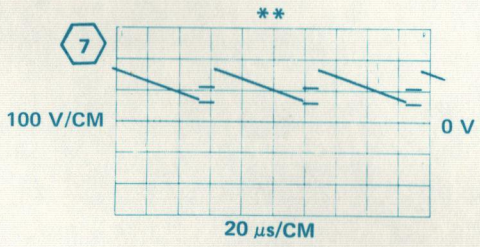


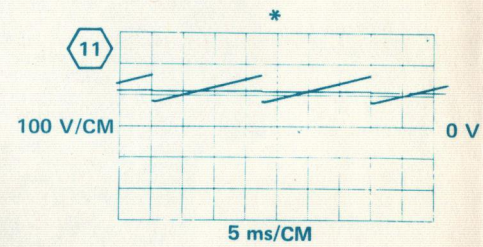


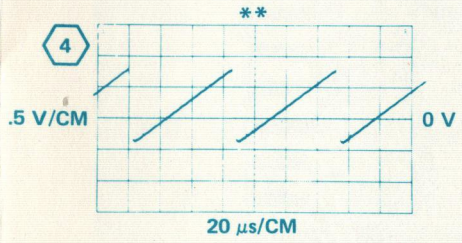


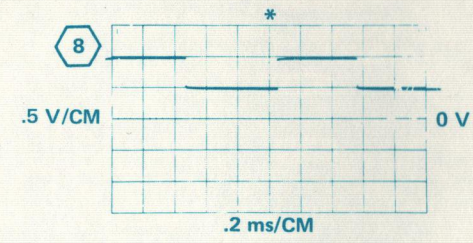


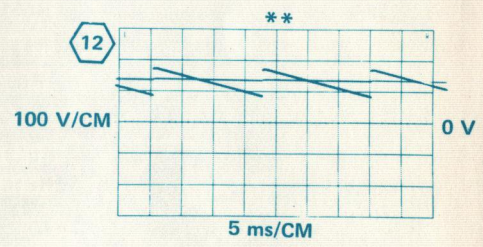












VOLTAGE AND WAVEFORM CONDITIONS

VOLTAGES

20,000 Ω/volt DC meter
No input Signals

Type 4501

MODE	WRITE ONLY
STORE/NON-STORE	NON-STORE
PROGRAM	LOCAL

Type 4501

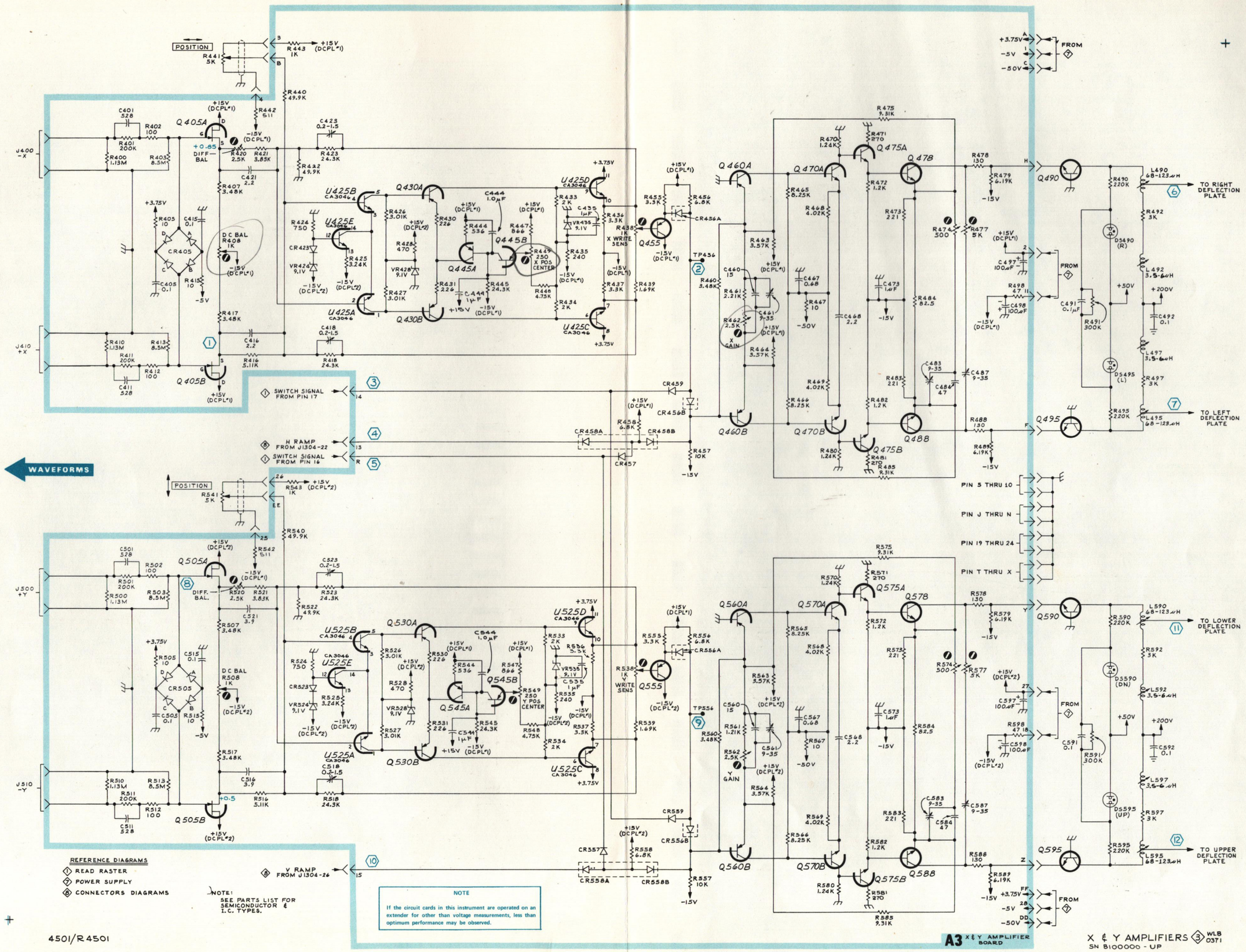
STORE/NON-STORE	NON-STORE
BACKGROUND	DARK
PROGRAM	LOCAL

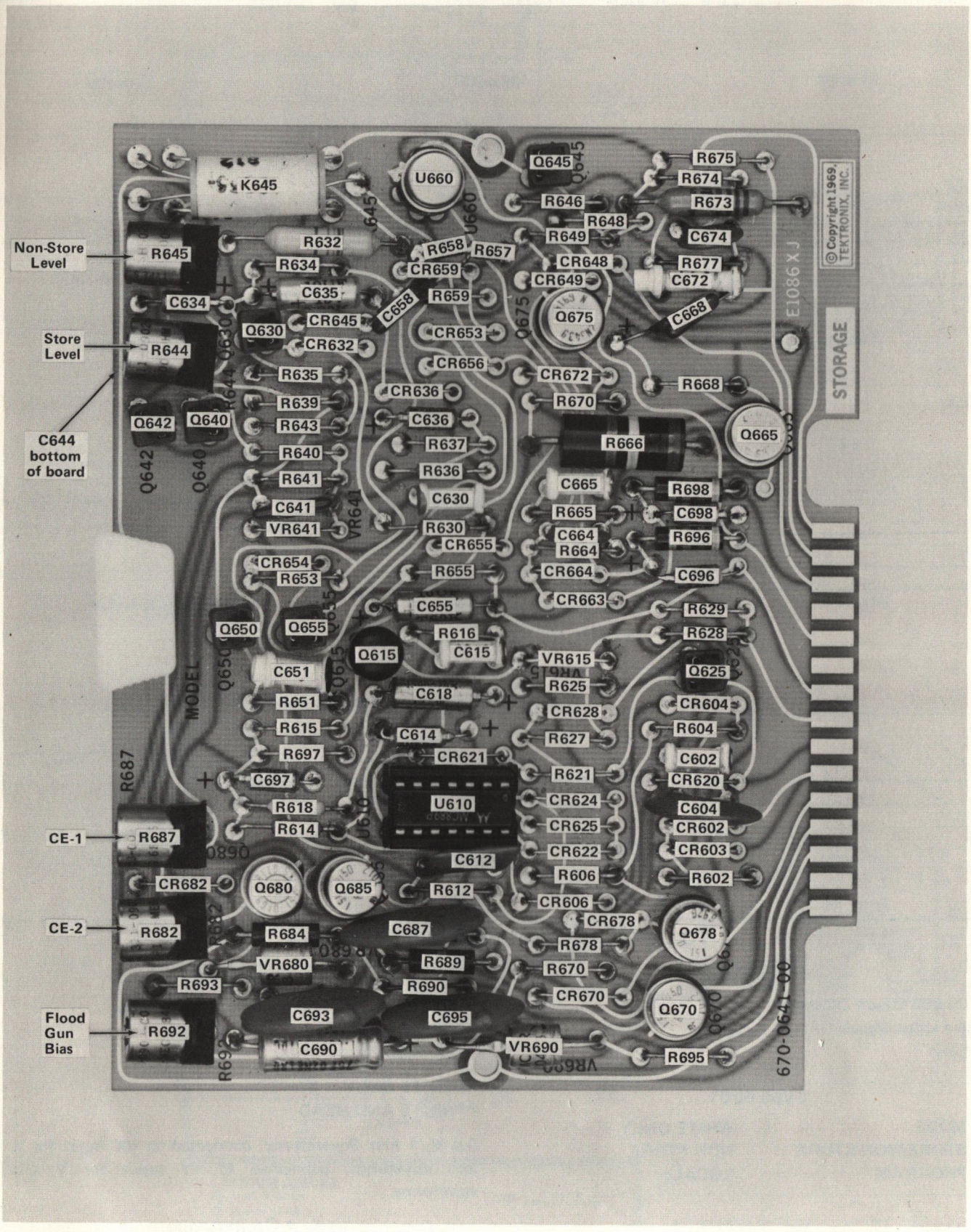
*WRITE ONLY
**WRITE AND READ

0.5 V, 1 kHz Squarewave: connected to +X Input for X axis waveforms; connected to +Y Input for Y axis waveforms.

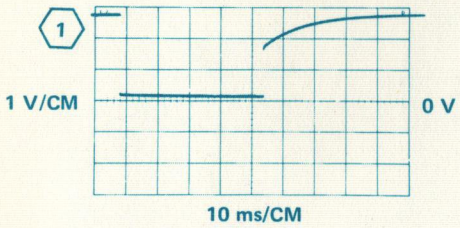
Test Oscilloscope

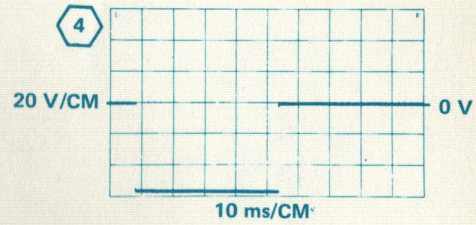
Trigger	+INT
	AC
10X Probe	DC Coupled

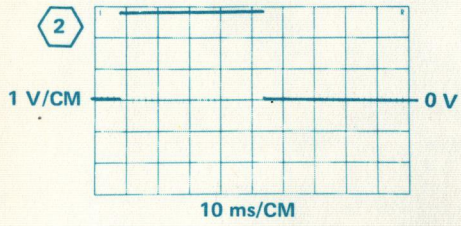

POSITION
R441 5K
R443 1K
+15V (DCPL*1)
R440 49.9K
R442 511
-15V (DCPL*1)
C401 528
R402 100
R401 200K
R400 1.13M
R403 8.5M
Q405A
+0.85 DIFF BAL
R420 2.5K
R421 3.83K
C421 2.2
R407 3.48K
C423 0.2-1.5
R423 24.3K
R432 49.9K
J400 -X
U425B CA3046
U425E CA3046
U425A CA3046
Q430A
Q430B
Q445A
Q445B
U425D CA3046
U425C CA3046
R424 750
CR423
VR424 9.1V
R425 3.24K
R426 3.01K
R427 3.01K
R428 470
VR428 9.1V
R430 226
R431 226
R444 536
C444 1.0µF
C444 1µF
R445 24.3K
R447 866
R449 250 X POS CENTER
R446 4.75K
R433 2K
C435 1µF
VR435 9.1V
R435 240
R434 2K
R436 3.3K
R438 1K X WRITE SENS
R437 3.3K
R439 1.69K
+3.75V
R405 10
C415 0.1
CR405
C405 0.1
R415 10
DC BAL R408 1K
R417 3.48K
C416 2.2
R416 5.11K
C418 0.2-1.5
R418 24.3K
J410 +X
R410 1.13M
R411 200K
R413 8.5M
R412 100
C411 528
Q405B
R455 3.3K
R456 6.8K
CR456A
Q455
TP456
R460 3.48K
C460 15
R461 2.21K
C461 9-35
R462 2.5K X GAIN
R463 3.57K
R464 3.57K
CR459
CR456B
R458 6.8K
CR458A
CR458B
R457 10K
CR457
Q460A
Q460B
R465 8.25K
R468 4.02K
C467 0.68
R467 10
C468 2.2
R469 4.02K
R466 8.25K
Q470A
Q470B
R470 1.24K
R471 270
R475 9.31K
Q475A
Q475B
R472 1.2K
R473 221
C473 1µF
R484 82.5
R482 1.2K
R483 221
C483 9-35
C484 47
R480 1.24K
R481 270
R485 9.31K
Q478
Q488
R478 130
R479 6.19K
R474 500
R477 5K
C497 100µF
R498 47 11
C498 100µF
R488 130
R489 6.19K
Q490
Q495
R490 220K
R495 220K
L490 68-123µH
L495 68-123µH
TO RIGHT DEFLECTION PLATE
TO LEFT DEFLECTION PLATE
R492 3K
L492 3.5-6µH
D5490 (R)
+50V
+200V
C492 0.1
L497 3.5-6µH
R497 3K
D5495 (L)
C491 0.1µF
R491 300K
FROM 7
+3.75V
-5V
-50V
PIN 5 THRU 10
PIN J THRU N
PIN 19 THRU 24
PIN T THRU X
SWITCH SIGNAL FROM PIN 17
H RAMP FROM J1304-22
SWITCH SIGNAL FROM PIN 16
V RAMP FROM J1304-26
WAVEFORMS
REFERENCE DIAGRAMS
1 READ RASTER
7 POWER SUPPLY
8 CONNECTORS DIAGRAMS
NOTE: SEE PARTS LIST FOR SEMICONDUCTOR & I.C. TYPES.
NOTE
If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.
J500 +Y
J510 -Y
R501 200K
R500 1.13M
R503 8.5M
Q505A
DIFF. BAL.
R520 2.5K
R521 3.83K
C521 3.9
R507 3.48K
C523 0.2-1.5
R523 24.3K
R522 49.9K
U525B CA3046
U525E CA3046
U525A CA3046
Q530A
Q530B
Q545A
Q545B
U525D CA3046
U525C CA3046
R524 750
CR523
VR524 9.1V
R525 3.24K
R526 3.01K
R527 3.01K
R528 470
VR528 9.1V
R530 226
R531 226
R544 536
C544 1µF
R545 24.3K
R547 866
R549 250 Y POS CENTER
R548 4.75K
R533 2K
C535 1µF
VR535 9.1V
R535 240
R534 2K
R536 3.3K
R538 1K WRITE SENS
R537 3.3K
R539 1.69K
R505 10
C515 0.1
CR505
C505 0.1
R515 10
DC BAL R508 1K
R517 3.48K
C516 3.9
R516 5.11K
C518 0.2-1.5
R518 24.3K
R510 1.13M
R511 200K
R513 8.5M
R512 100
C511 528
Q505B
R555 3.3K
R556 6.8K
CR556A
Q555
TP556
R560 3.48K
C560 15
R561 1.21K
C561 9-35
R562 2.5K Y GAIN
R563 3.57K
R564 3.57K
CR559
CR556B
R558 6.8K
CR558A
CR558B
R557 10K
CR557
Q560A
Q560B
R565 8.25K
R568 4.02K
C567 0.68
R567 10
C568 2.2
R569 4.02K
R566 8.25K
Q570A
Q570B
R570 1.24K
R571 270
R575 9.31K
Q575A
Q575B
R572 1.2K
R573 221
C573 1µF
R584 82.5
R582 1.2K
R583 221
C583 9-35
C584 47
R580 1.24K
R581 270
R585 9.31K
Q578
Q588
R578 130
R579 6.19K
R574 500
R577 5K
C597 100µF
R598 47 18
C598 100µF
R588 130
R589 6.19K
Q590
Q595
R590 220K
R595 220K
L590 68-123µH
L595 68-123µH
TO LOWER DEFLECTION PLATE
TO UPPER DEFLECTION PLATE
R592 3K
L592 3.5-6µH
D5590 (DN)
+50V
+200V
C592 0.1
L597 3.5-6µH
R597 3K
D5595 (UP)
C591 0.1
R591 300K
FROM 7
+3.75V
-5V
-50V
FF
28
DD
A3 X & Y AMPLIFIER BOARD
X & Y AMPLIFIERS 3 WLB 0371
SN B100000 - UP
4501/R4501
A

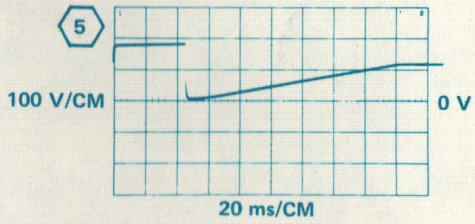

Non-Store Level
Store Level
C644 bottom of board
CE-1
CE-2
Flood Gun Bias
K645
U660
Q645
R675
R674
R673
R646
R648
R649
C674
R632
R658
R657
CR659
CR648
CR649
R677
C672
R645
R634
C635
C658
R659
Q675
C668
C634
CR645
CR653
Q630
CR632
CR656
CR672
R668
R644
R635
CR636
R670
R639
C636
R666
Q665
Q642
Q640
R643
R637
R640
R636
R641
C665
R698
C641
C630
R665
C698
VR641
R630
C664
R696
CR655
R664
CR654
R653
R655
CR664
C696
C655
CR663
R629
Q650
Q655
R616
R628
Q615
C615
VR615
C651
R625
Q625
C618
CR628
CR604
R651
R627
R604
R615
C614
CR621
C602
R697
R621
CR620
C697
U610
CR624
C604
R618
CR625
CR602
R614
C612
CR622
CR603
CR682
Q680
Q685
R612
R606
R602
CR606
R682
R684
C687
CR678
Q678
R678
VR680
R689
R670
R693
R690
CR670
Q670
C693
C695
R692
C690
VR690
R695
R687
MODEL
STORAGE
E1086 XJ
© Copyright 1969, TEKTRONIX, INC.
670-0641-00

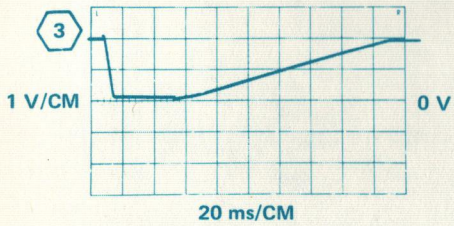
A

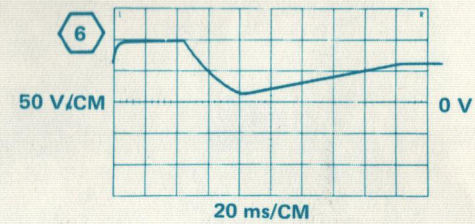












VOLTAGE AND WAVEFORM CONDITIONS

VOLTAGES

20,000 Ω/volt DC meter
No input Signals

Type 4501

MODE	WRITE ONLY
STORE/NON-STORE	NON-STORE
PROGRAM	LOCAL

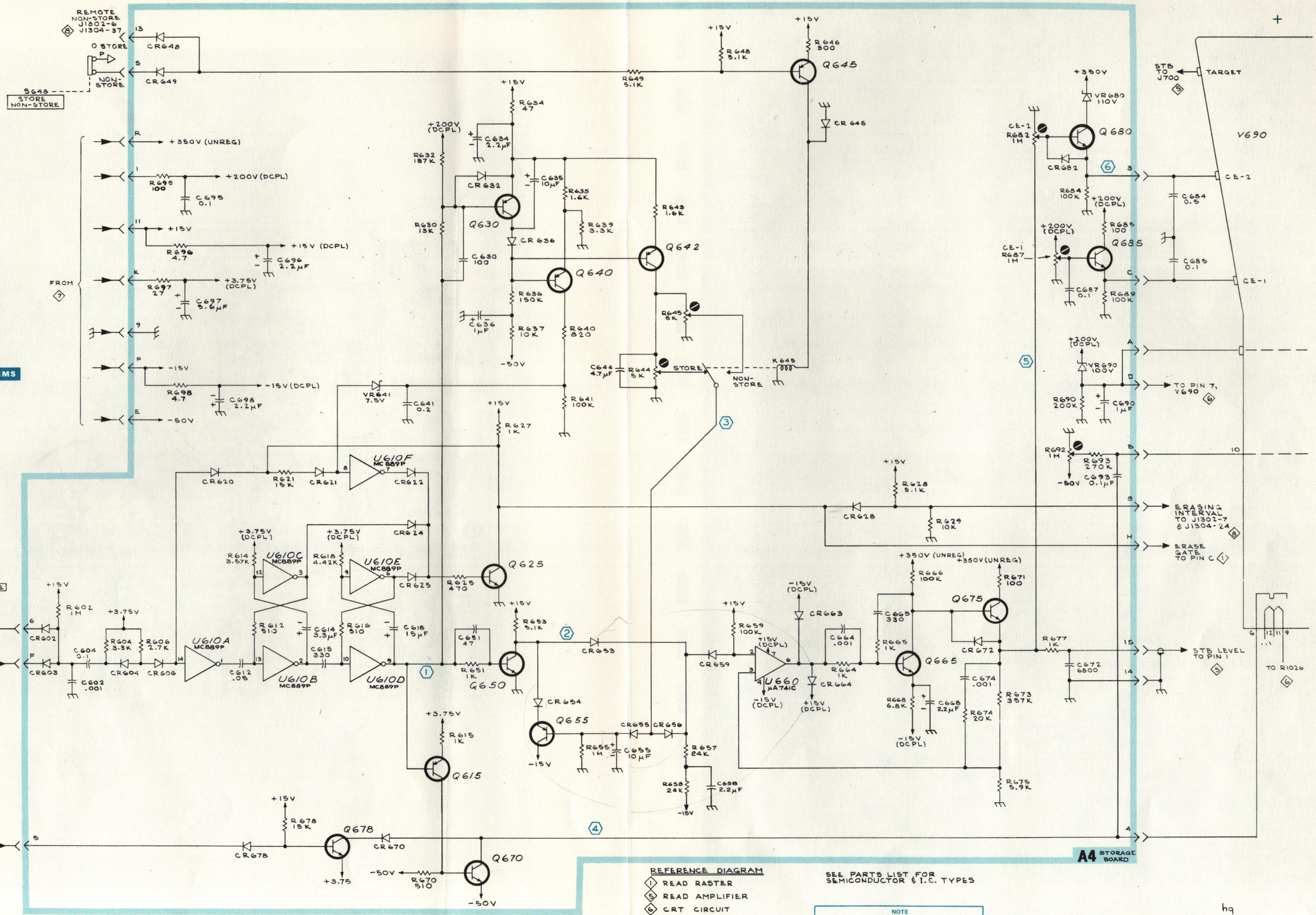
Type 4501

MODE	WRITE AND READ
STORE/NON-STORE	NON-STORE
PROGRAM	LOCAL
BACKGROUND	DARK

Test Oscilloscope

Trigger	+INT
	AC
10X Probe	DC Coupled

WAVEFORMS



REFERENCE DIAGRAM
- 1 READ RASTER
- 5 READ AMPLIFIER
- 6 CRT CIRCUIT
- 8 CONNECTORS DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR & I.C. TYPES

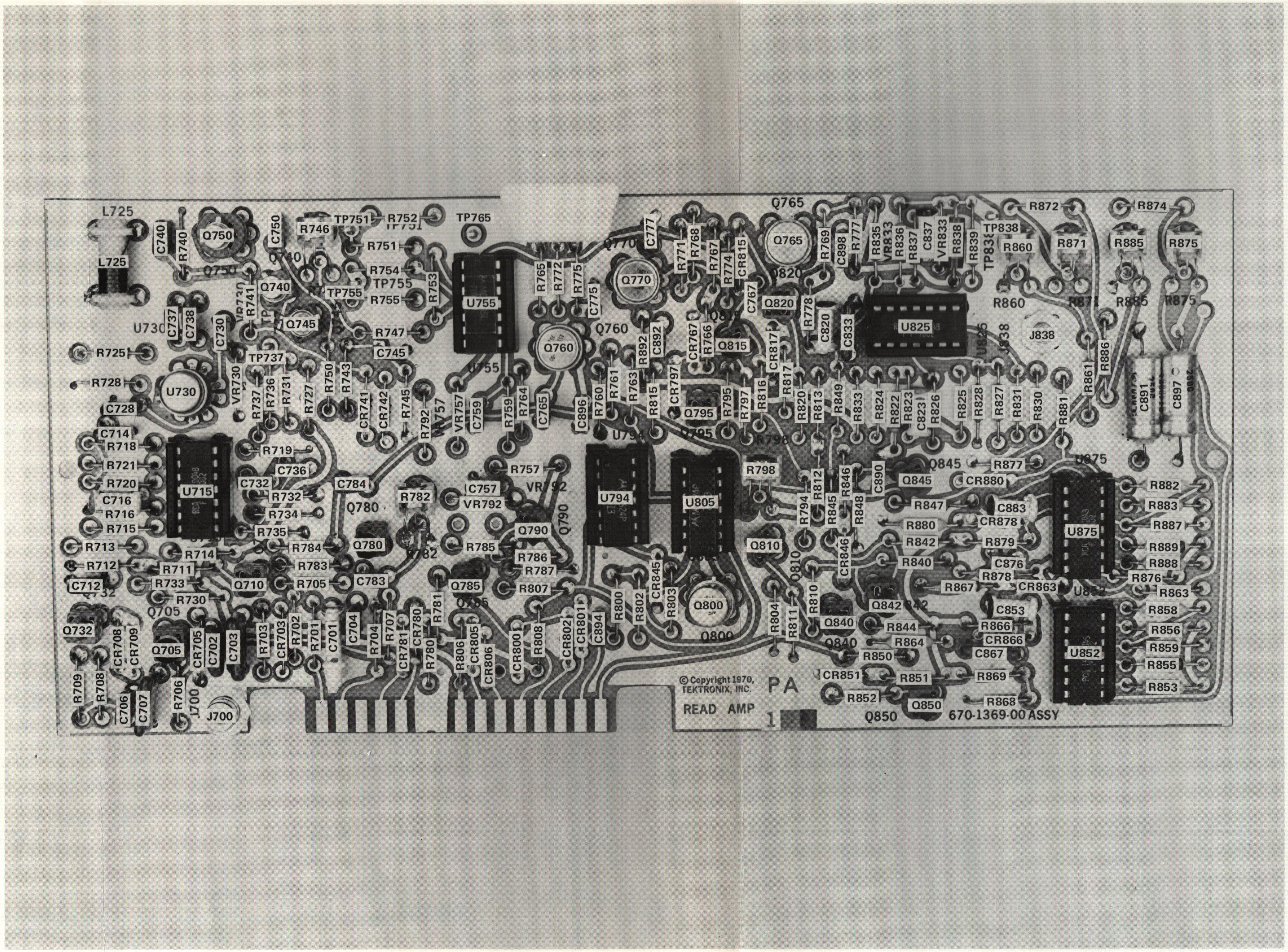
NOTE

If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.

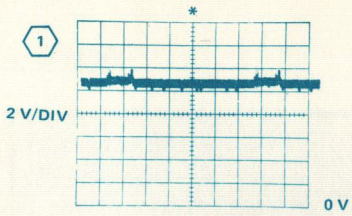
hq 0371

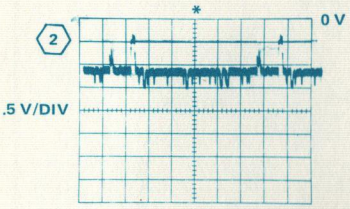
STORAGE SYSTEM 4

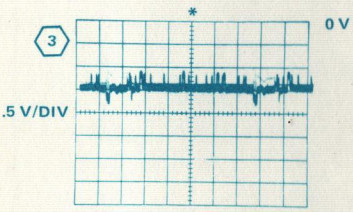
SN B100000 - UP

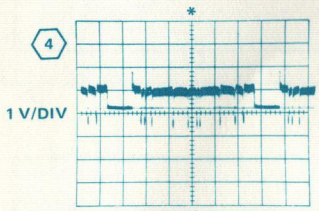


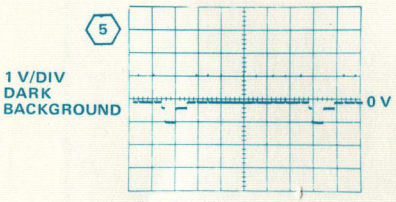
READ AMPLIFIER Circuit Card

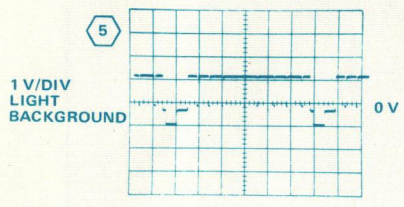


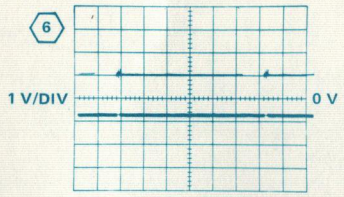


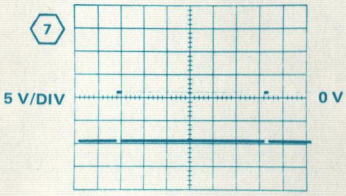


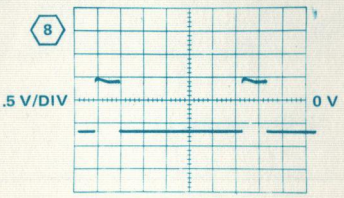


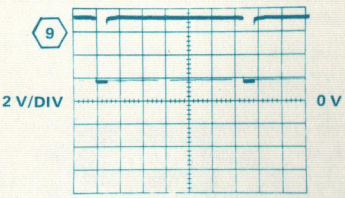


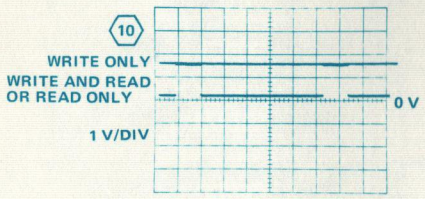


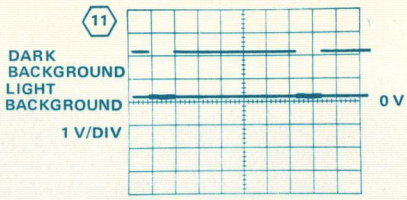


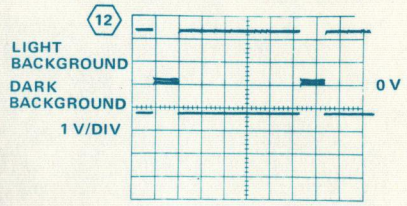


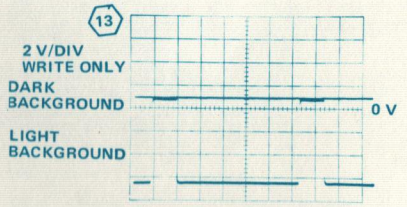


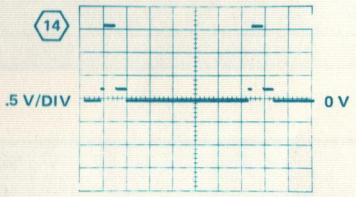


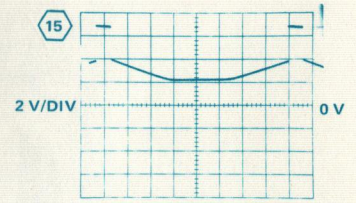


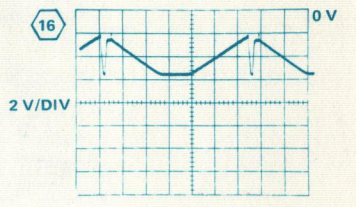












VOLTAGE AND WAVEFORM CONDITIONS

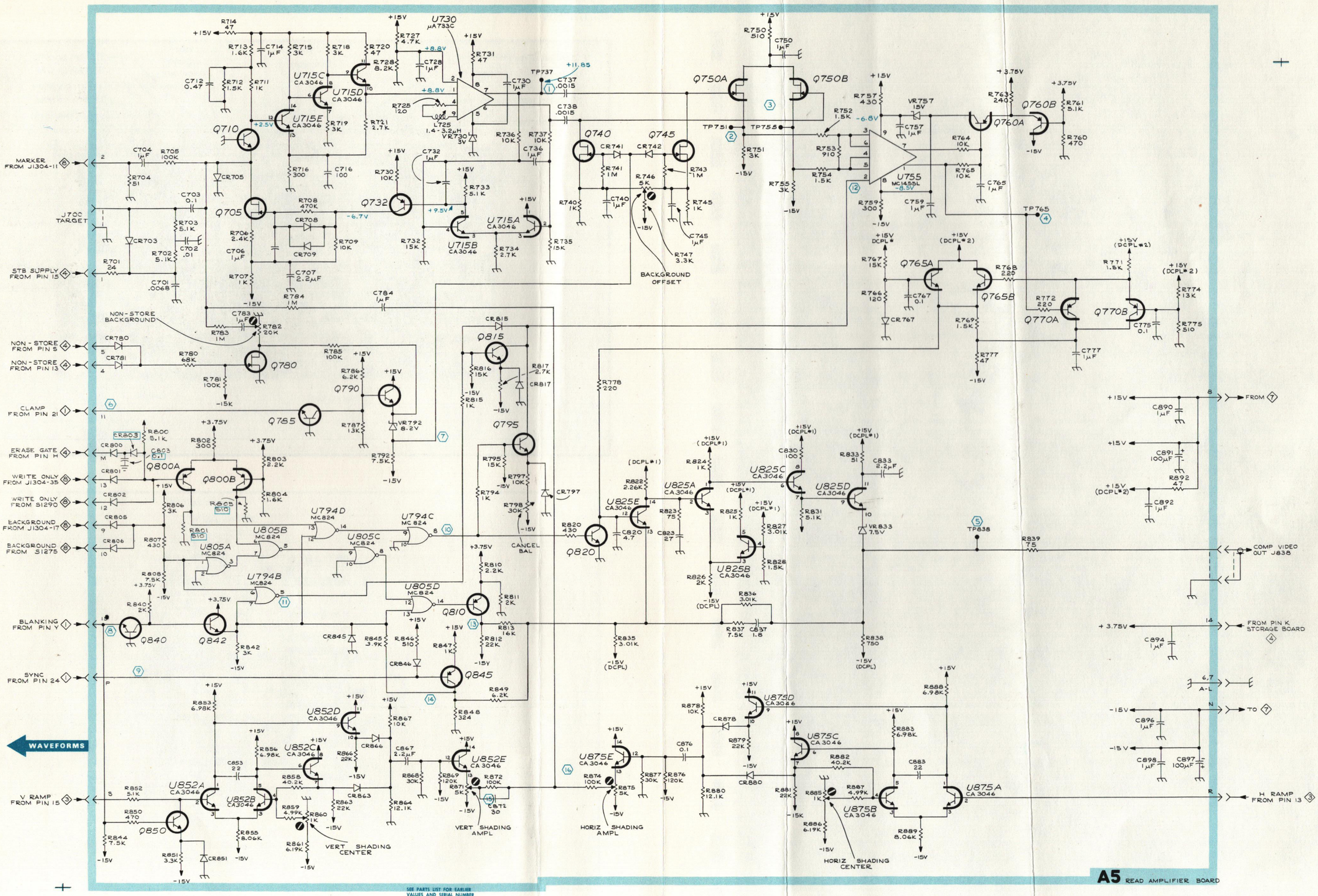
Type 4501

Set to STORE' LOCAL, and WRITE AND READ unless noted otherwise.

Test Oscilloscope

Trigger +EXT +EXT (composite blanking) AC coupling

*A 5.1 kΩ resistor was used in series with probe tip at points 1, 2, 3, and 4.



NOTE

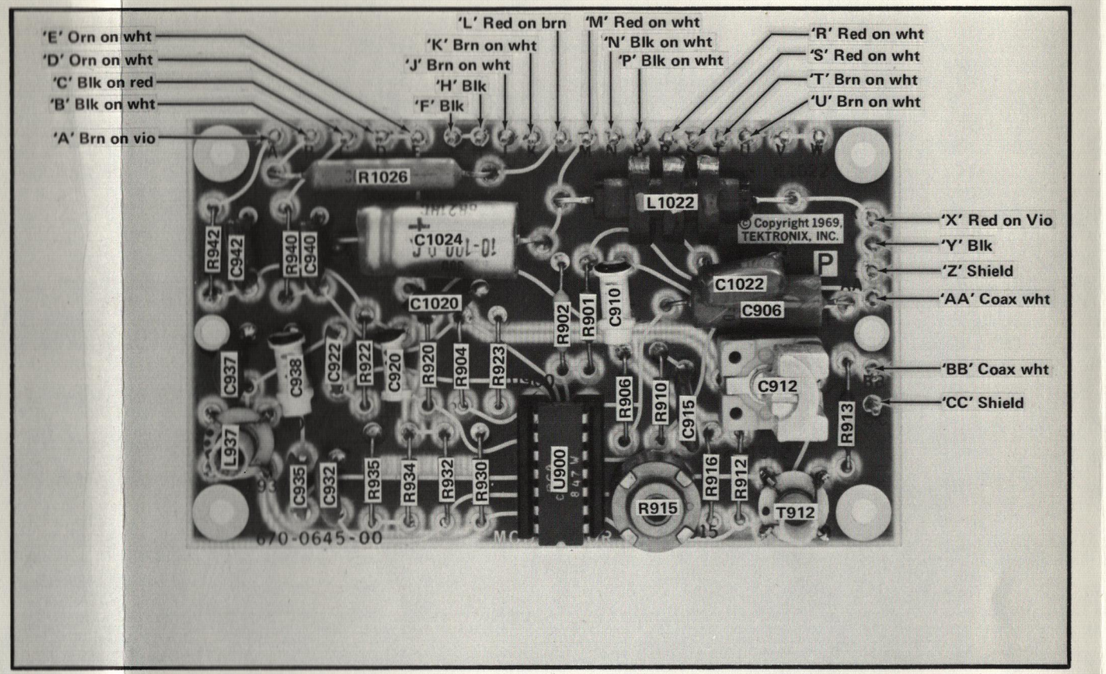
If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

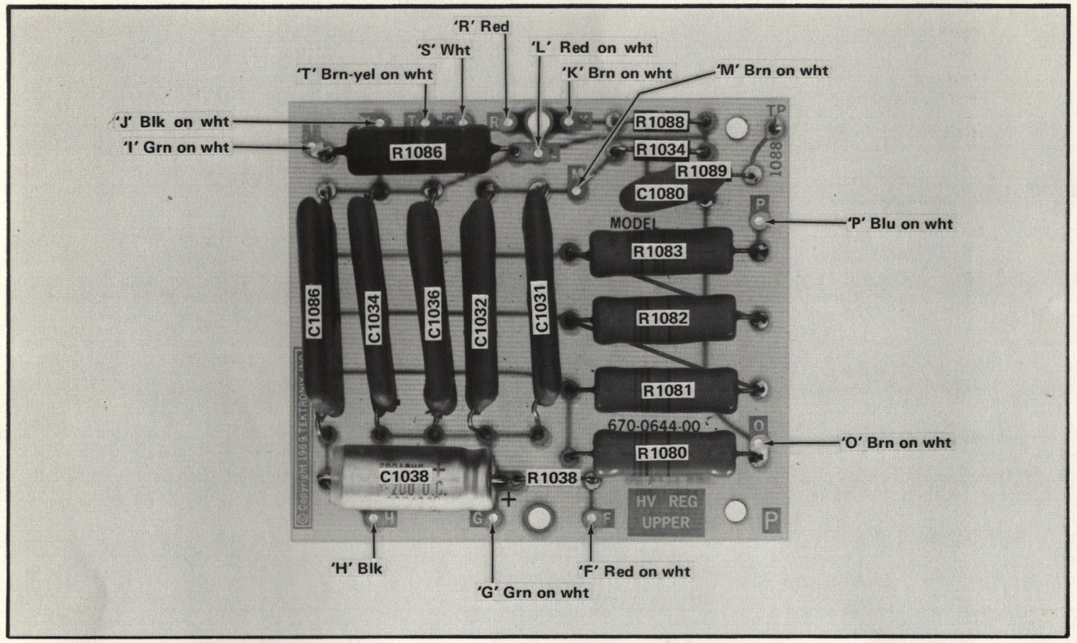
TYPE 4501/R4501

READ AMPLIFIER ⟨5⟩ 372 WS

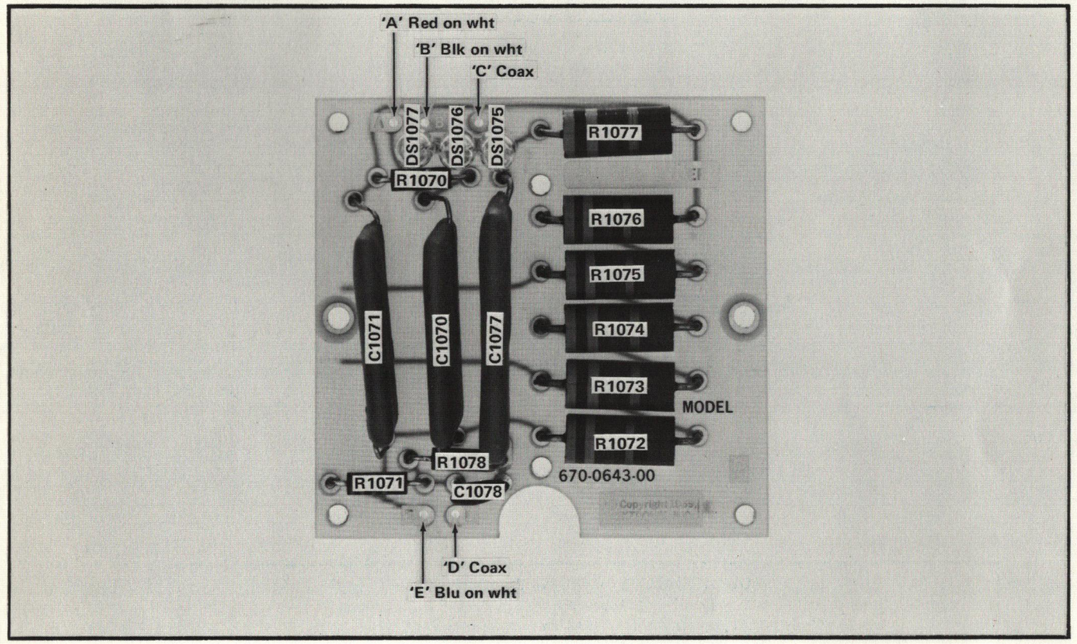
SN B100000 -UP


'E' Orn on wht
'D' Orn on wht
'C' Blk on red
'B' Blk on wht
'A' Brn on vio
'L' Red on brn
'K' Brn on wht
'J' Brn on wht
'H' Blk
'F' Blk
'M' Red on wht
'N' Blk on wht
'P' Blk on wht
'R' Red on wht
'S' Red on wht
'T' Brn on wht
'U' Brn on wht
'X' Red on Vio
'Y' Blk
'Z' Shield
'AA' Coax wht
'BB' Coax wht
'CC' Shield
R1026
L1022
C1024
C1022
C906
C912
C1020
R942
C942
R940
C940
C937
C938
C922
R922
C920
R920
R904
R923
L937
C935
C932
R935
R934
R932
R930
U900
R902
R901
C910
R906
R910
C915
R916
R912
R915
R913
T912
Copyright 1969, TEKTRONIX, INC.
670-0645-00

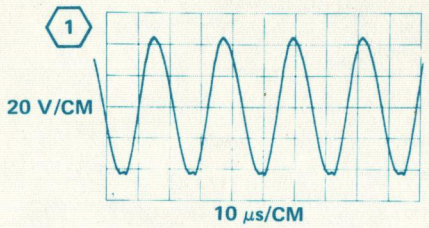
A

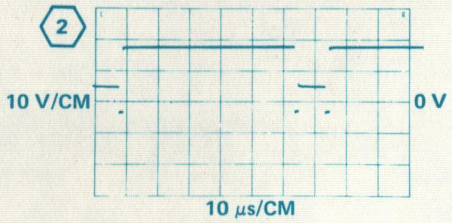

'R' Red
'S' Wht
'L' Red on wht
'K' Brn on wht
'M' Brn on wht
'T' Brn-yel on wht
'J' Blk on wht
'I' Grn on wht
'P' Blu on wht
'O' Brn on wht
'H' Blk
'G' Grn on wht
'F' Red on wht
R1086
R1088
R1034
R1089
C1080
R1083
R1082
R1081
R1080
R1038
C1038
C1086
C1034
C1036
C1032
C1031
MODEL
670-0644-00
HV REG UPPER

A


'A' Red on wht
'B' Blk on wht
'C' Coax
DS1077
DS1076
DS1075
R1070
R1077
R1076
R1075
R1074
R1073
R1072
C1071
C1070
C1077
R1078
R1071
C1078
MODEL
670-0643-00
'D' Coax
'E' Blu on wht

A





VOLTAGE AND WAVEFORM CONDITIONS

VOLTAGES

20,000 Ω/volt DC meter
No input Signals

Type 4501

MODE	WRITE ONLY
STORE/NON-STORE	NON-STORE
PROGRAM	LOCAL

Type 4501

MODE	WRITE ONLY
STORE/NON-STORE	NON-STORE
PROGRAM	LOCAL
BACKGROUND	DARK

All waveforms taken while pressing ERASE switch.

Test Oscilloscope

Trigger	+EXT (Erase Interval out)
	AC
10X Probe	DC Coupled

NOTES

1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
2. ⏚A INDICATES PIN NUMBER

REFERENCE DIAGRAMS

- ◇2◇ Z AXIS AMPLIFIER
- ◇4◇ STORAGE SYSTEM
- ◇5◇ READ AMPLIFIER
- ◇7◇ POWER SUPPLY

NOTE

● If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.

WAVEFORMS

P/O A5

P/O A7 HV#1 BOARD

A8 HV#2 BOARD

P/O A9 REGULATOR BOARD

A6 RF MODULATOR BOARD

P/O A9 POWER SUPPLY BOARD

P/O A7 HV#1 BOARD

Part # 154-0616-00 #600

hq 0371

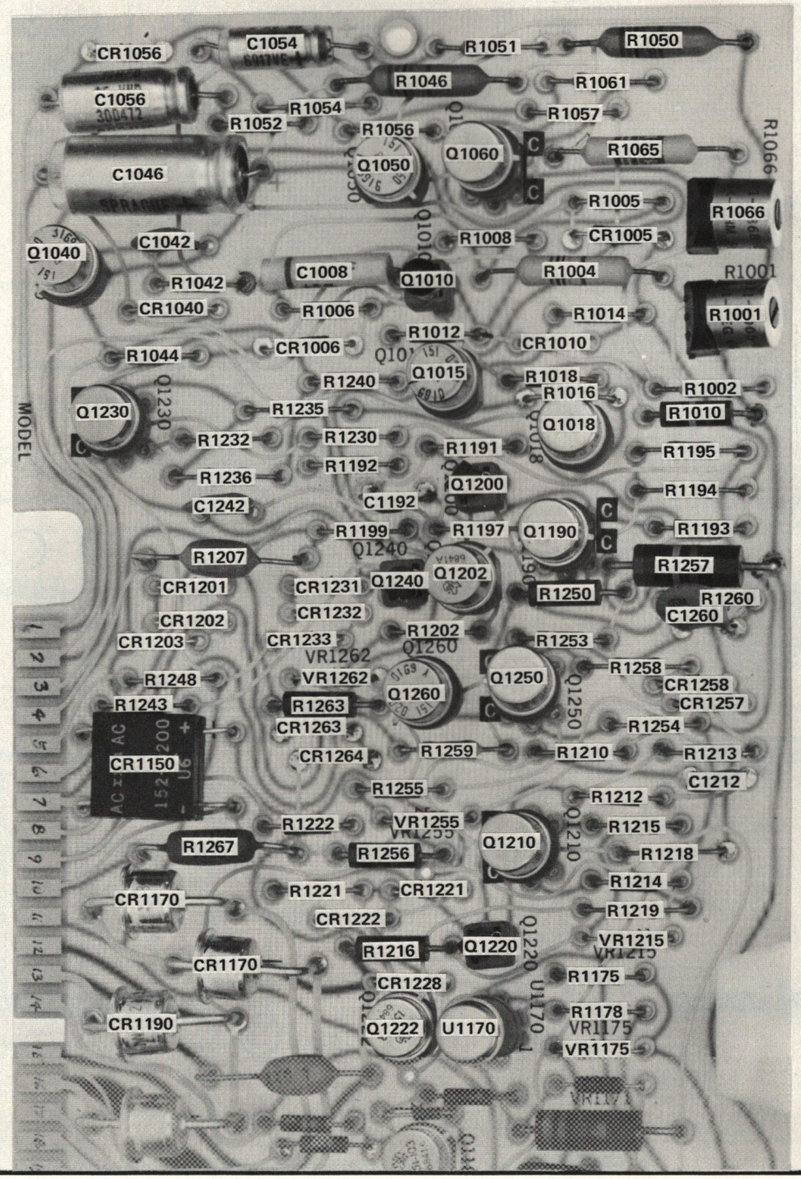
TYPE 4501/R4501

CRT CIRCUIT ◇6◇

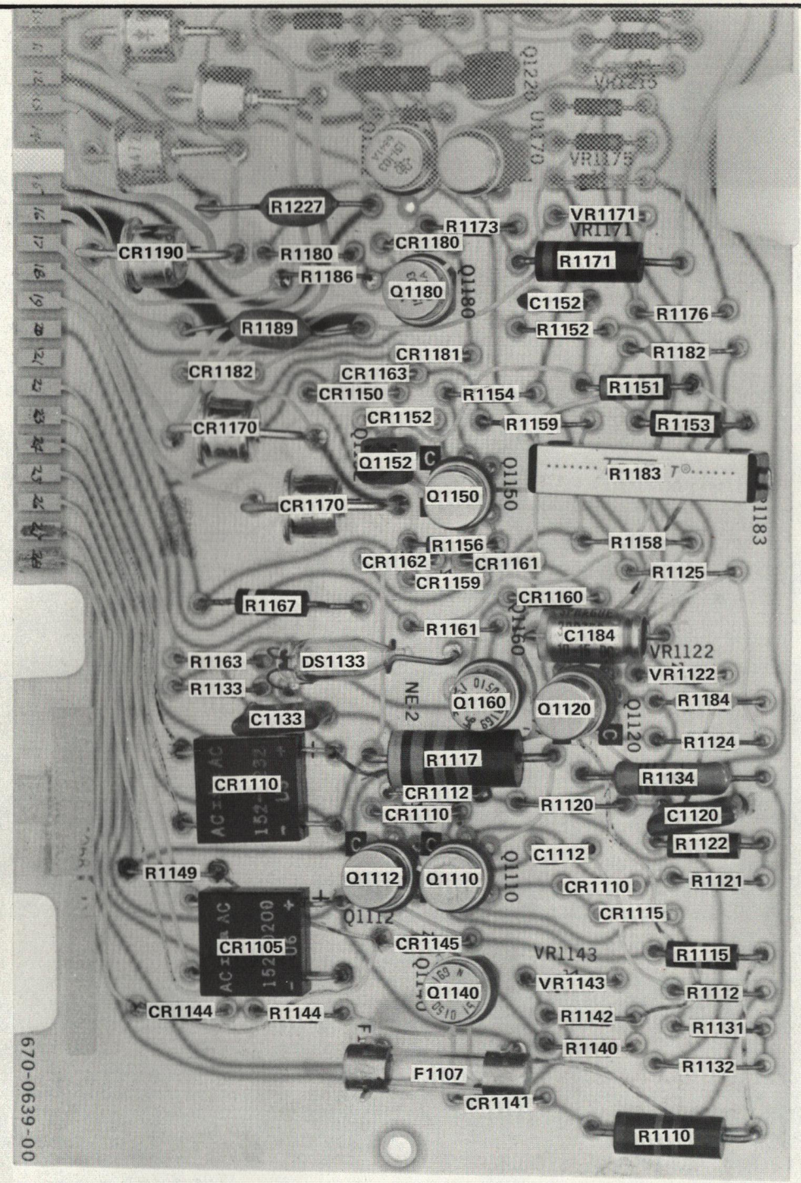
SN B100000 - UP

CRT CIRCUIT

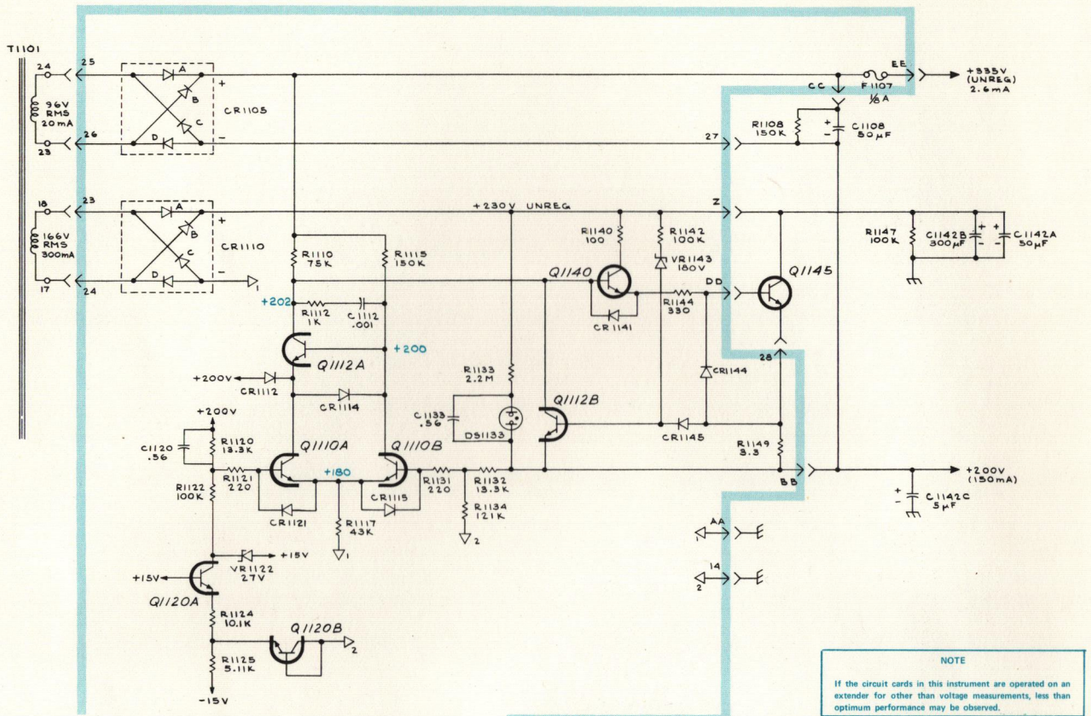
6

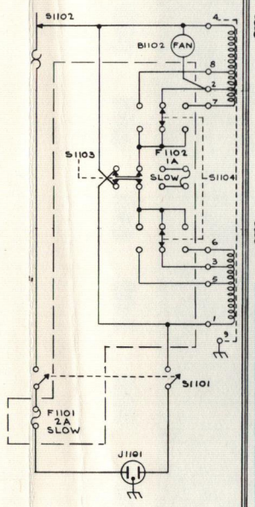

CR1056
C1054
R1051
R1050
R1046
R1061
C1056
R1054
R1052
R1056
R1057
C1046
Q1050
Q1060
R1065
R1005
R1066
C1042
R1008
CR1005
Q1040
C1008
Q1010
R1004
R1042
R1001
CR1040
R1006
R1014
R1012
CR1006
CR1010
R1044
Q1015
R1240
R1018
R1016
R1002
Q1230
R1235
R1010
Q1018
R1232
R1230
R1191
R1195
R1236
R1192
Q1200
R1194
C1242
C1192
R1199
R1197
Q1190
R1193
R1207
Q1240
R1257
CR1201
CR1231
Q1202
R1250
R1260
CR1202
CR1232
C1260
CR1203
CR1233
R1202
R1253
VR1262
R1248
VR1262
Q1260
Q1250
R1258
R1243
R1263
CR1258
CR1150
CR1263
CR1257
R1254
CR1264
R1259
R1210
R1213
R1255
C1212
R1212
R1222
VR1255
R1215
R1267
R1256
Q1210
R1218
R1221
CR1221
R1214
CR1170
CR1222
R1219
R1216
Q1220
VR1215
CR1170
R1175
CR1228
R1178
CR1190
Q1222
U1170
VR1175
MODEL

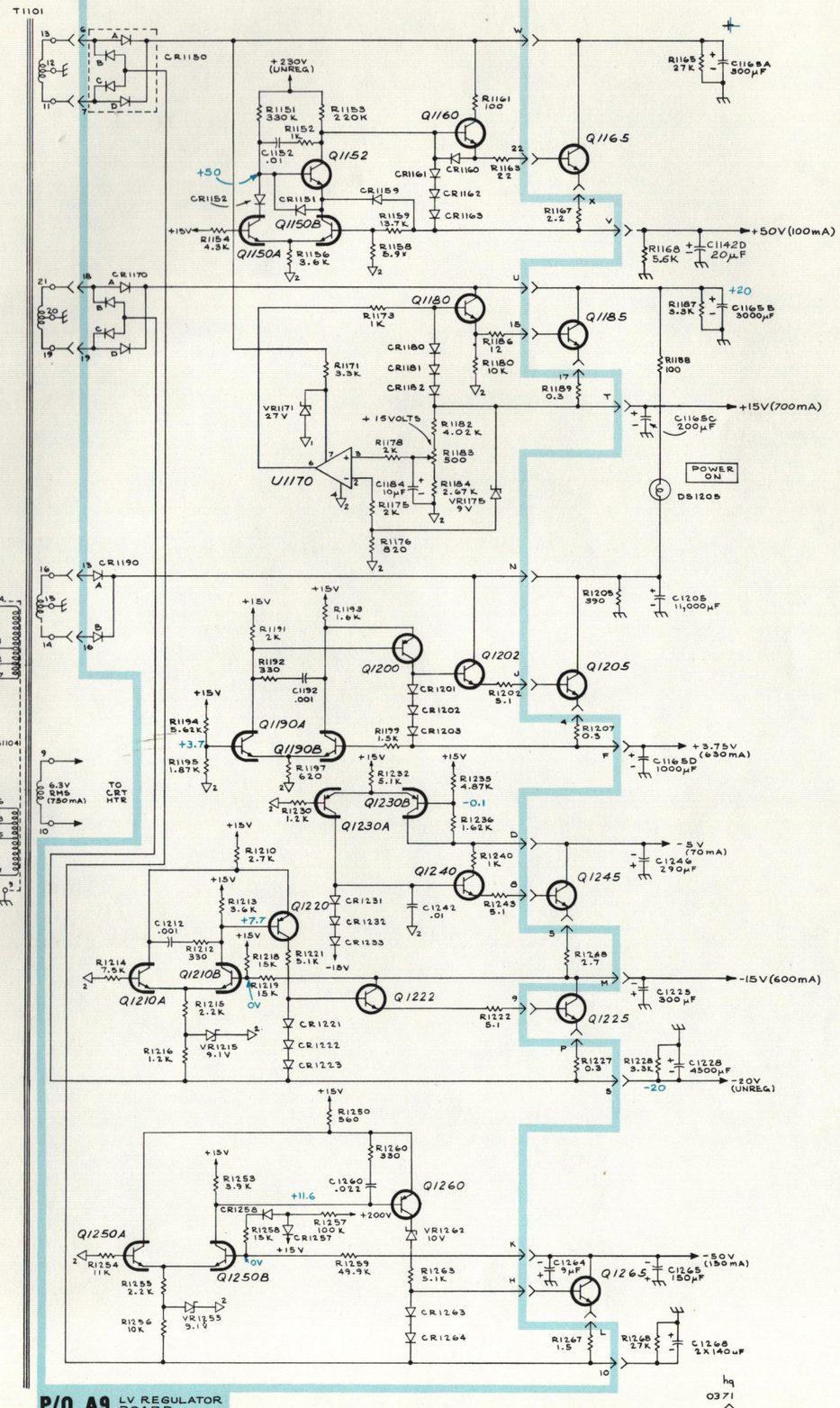
A

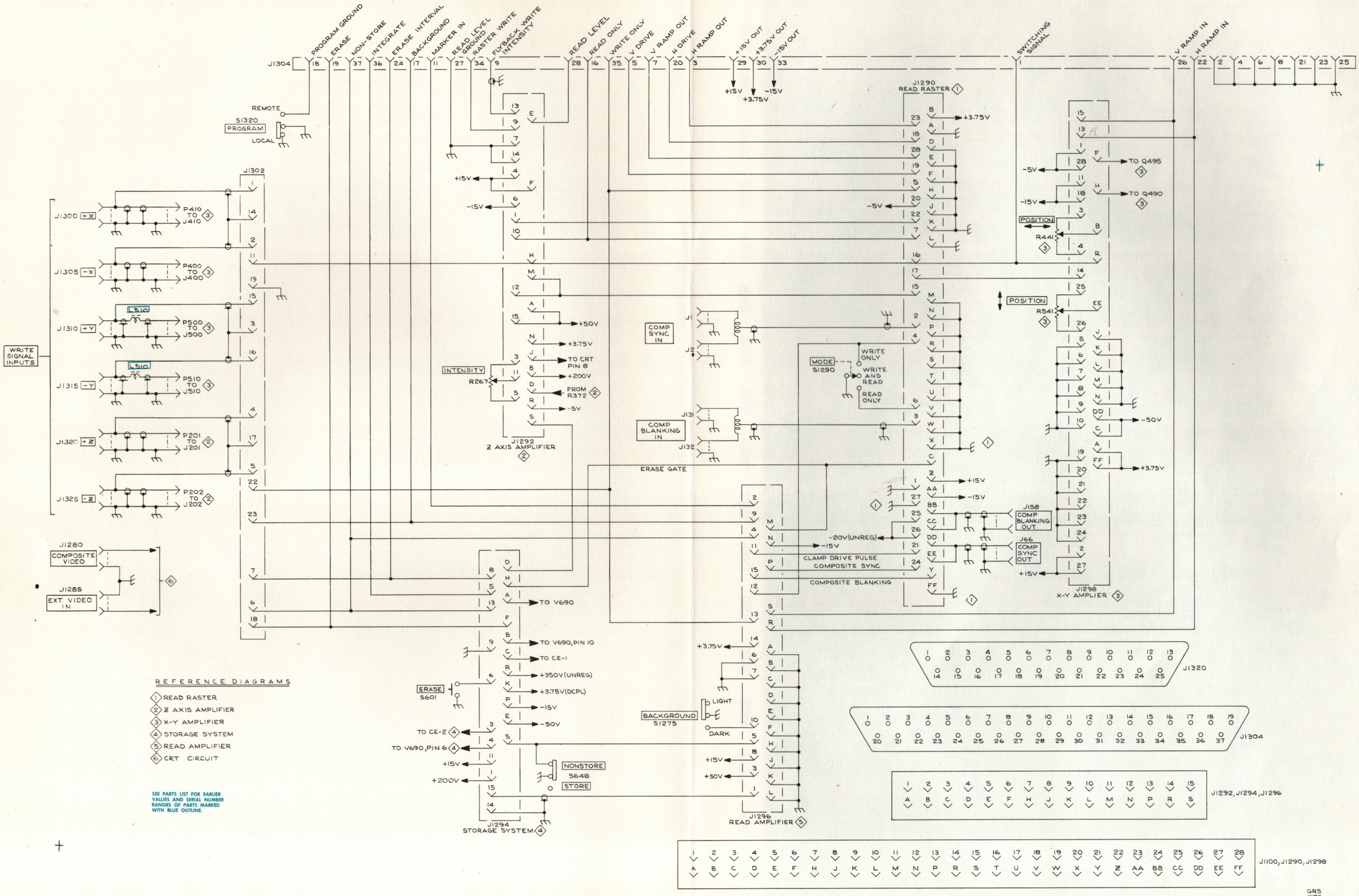

R1227
R1173
VR1171
CR1190
R1180
CR1180
R1171
R1186
Q1180
C1152
R1189
R1176
R1152
CR1181
R1182
CR1182
CR1163
R1151
CR1150
R1154
CR1152
R1159
R1153
CR1170
Q1152
R1183
Q1150
CR1170
R1156
R1158
CR1162
CR1161
R1125
CR1159
R1167
CR1160
R1161
C1184
R1163
DS1133
VR1122
R1133
Q1160
Q1120
R1184
C1133
R1124
R1117
CR1110
R1134
CR1112
R1120
CR1110
C1120
R1122
C1112
R1149
Q1112
Q1110
CR1110
R1121
CR1115
CR1105
CR1145
VR1143
R1115
VR1143
Q1140
R1112
CR1144
R1144
R1142
R1131
R1140
R1132
F1107
CR1141
R1110
670-0639-00

A


T1101
CR1105
96V RMS 20mA
CR1110
166V RMS 300mA
+230V UNREG.
+333V (UNREG) 2.6mA
F1107 1/8A
C1108 50µF
R1108 150K
R1110 75K
R1115 150K
R1140 100
R1142 100K
VR1143 180V
Q1140
Q1145
CR1141
R1144 330
CR1144
CR1145
R1147 100K
C1142B 300µF
C1142A 50µF
+202
R1112 1K
C1112 .001
+200
Q1112A
Q1112B
+200V
CR1112
CR1114
C1133 .56
DS1133
R1133 2.2M
C1120 .56
R1120 19.3K
Q1110A
Q1110B
+180
R1121 220
R1122 100K
CR1121
CR1115
R1131 220
R1132 19.3K
R1134 121K
R1117 43K
+15V
VR1122 27V
Q1120A
Q1120B
R1124 10.1K
R1125 5.11K
-15V
+200V (150mA)
C1142C 5µF
AA
14
BB
DD
CC
EE
NOTE
If the circuit cards in this instrument are operated on an extender for other than voltage measurements, less than optimum performance may be observed.
P/O A9 LV REGULATOR BOARD
VOLTAGE CONDITIONS
20,000 Ω/volt DC meter
No input Signals
Type 4501
MODE WRITE ONLY
STORE/NON-STORE NON-STORE
PROGRAM LOCAL
NOTE:
DENOTES GROUND TO CHASSIS THRU PIN AA
DENOTES GROUND TO CHASSIS THRU PIN 14
SEE PARTS LIST FOR SEMICONDCTOR TYPES


S1102
B1102 FAN
S1103
F1102 1A SLOW
S1104
F1101 2A SLOW
S1101
J1101
6.3V RMS (750mA)
TO CRT HTR


T1101
CR1150
+230V (UNREG)
R1151 330K
R1153 220K
R1152 1K
C1152 .01
Q1152
Q1150A
Q1150B
+50
CR1152
CR1151
CR1159
R1159 13.7K
R1158 8.97
R1156 3.6K
R1154 4.3K
+15V
Q1160
R1161 100
CR1160
CR1161
CR1162
CR1163
R1163 22
Q1165
R1167 2.2
R1165 27K
C1165A 300µF
+50V(100mA)
R1168 5.6K
C1142D 20µF
CR1170
Q1180
Q1185
R1173 1K
CR1180
CR1181
CR1182
R1171 3.3K
VR1171 27V
U1170
+15VOLTS
R1182 4.02K
R1183 500
R1178 2K
C1184 10µF
R1184 2.67K
VR1175 9V
R1175 2K
R1176 820
R1186 12
R1180 10K
R1189 0.3
R1188 100
+20
C1165B 3000µF
+15V(700mA)
C1165C 200µF
POWER ON
DS1205
CR1190
R1205 390
C1205 11,000µF
R1191 2K
R1193 1.6K
Q1200
Q1202
Q1205
CR1201
CR1202
CR1203
R1202 5.1
R1207 0.3
R1192 330
C1192 .001
Q1190A
Q1190B
R1194 5.62K
+3.7
R1195 1.87K
R1197 620
R1199 1.5K
+3.75V (630mA)
C1165D 1000µF
R1232 5.1K
R1235 4.87K
-0.1
R1236 1.62K
Q1230B
Q1230A
R1230 1.2K
R1210 2.7K
Q1240
Q1245
R1240 1K
R1243 5.1
C1242 .01
-5V (70mA)
C1246 290µF
Q1220
CR1231
CR1232
CR1233
R1213 3.6K
+7.7
C1212 .001
R1212 330
R1214 7.5K
Q1210B
Q1210A
R1218 15K
R1219 15K
0V
R1221 5.1K
-15V
Q1222
R1222 5.1
R1248 2.7
-15V(600mA)
C1225 300µF
Q1225
R1218 2.2K
VR1215 9.1V
R1216 1.2K
CR1221
CR1222
CR1223
R1227 0.3
R1228 3.3K
C1228 4500µF
-20
-20V (UNREG)
R1250 560
R1260 330
C1260 .022
Q1260
+11.6
R1253 3.9K
CR1256
R1257 100K
+200V
R1258 15K
CR1257
VR1262 10V
Q1250A
Q1250B
R1254 11K
R1255 2.2K
R1259 49.9K
R1263 5.1K
VR1255 9.1V
R1256 10K
CR1263
CR1264
C1264 9µF
C1265 150µF
Q1265
-50V (150mA)
R1267 1.5
R1268 27K
C1268 2X140µF
P/O A9 LV REGULATOR BOARD
hq 0371
POWER SUPPLY 7
SN B100000 - UP



REFERENCE DIAGRAMS

1. READ RASTER
2. Z AXIS AMPLIFIER
3. X-Y AMPLIFIER
4. STORAGE SYSTEM
5. READ AMPLIFIER
6. CRT CIRCUIT

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF
MECHANICAL PARTS LIST & ILLUSTRATIONS

SECTION 9
MECHANICAL PARTS LIST

FIGURE 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-1	366-1026-00			2		KNOB, gray—POSITION
	- - - - - -			-		each knob includes:
	213-0153-00			1		SETSCREW, 5-40 x 0.125 inch, HSS
-2	366-1026-00			1		KNOB, gray—INTENSITY
	- - - - - -			-		knob includes:
	213-0153-00			1		SETSCREW, 5-40 x 0.125 inch, HSS
-3	- - - - - -			3		RESISTOR, variable
	- - - - - -			-		mounting hardware for each: *(not included w/resistor)*
-4	210-0207-00			1		LUG, solder, 0.375 ID x 0.625 inch OD, SE
	210-0012-00			1		WASHER, lock, internal, 0.375 ID x 0.500 inch OD
	210-0840-00			1		WASHER, flat, 0.390 ID x 0.563 inch OD
-5	210-0590-00			1		NUT, hex., 0.375-32 x 0.438 inch
-6	366-0215-01			1		KNOB, charcoal—MODE
-7	260-0798-00			1		SWITCH, lever—MODE
	- - - - - -			-		mounting hardware: *(not included w/switch)*
-8	220-0413-00			2		NUT, hex., 4-40 x 0.188 x 0.562 inch long
-9	260-0449-00			1		SWITCH, slide—STORE-NONSTORE
	- - - - - -			-		mounting hardware: *(not included w/switch)*
-10	210-0406-00			2		NUT, hex., 4-40 x 0.188 inch
-11	260-0449-00			1		SWITCH, slide—PROGRAM
	- - - - - -			-		mounting hardware: *(not included w/switch)*
	210-0406-00			2		NUT, hex., 4-40 x 0.188 inch
-12	260-0449-00			1		SWITCH, slide—BACKGROUND
	- - - - - -			-		mounting hardware: *(not included w/switch)*
	210-0406-00			3		NUT, hex., 4-40 x 0.188 inch
	131-0809-00			1		TERMINAL, stud
-13	260-0574-00			1		SWITCH, pushbutton—ERASE
	- - - - - -			-		mounting hardware: *(not included w/switch)*
-14	354-0055-00			1		RING, locking
	210-0902-00			1		WASHER, flat, 0.470 ID x 0.565 inch
-15	210-0473-00			1		NUT, 12-sided, 0.469-32 x 0.078 inch

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-16	260-0276-00			1		SWITCH, toggle—ON
	- - - - - -			-		mounting hardware: *(not included w/switch)*
	210-0414-00			1		NUT, hex., 0.469-32 x 0.563 inch
	354-0055-00			1		RING, locking
	210-0902-00			1		WASHER, flat, 0.470 ID x 0.656 inch OD
-17	210-0473-00			1		NUT, 12-sided, 0.469-32 x 0.563 inch
-18	136-0164-00			1		SOCKET, light, w/hardware
-19	352-0067-00			4		HOLDER, nylon
	- - - - - -			-		mounting hardware for each: *(not included w/holder)*
-20	211-0109-00			1		SCREW, 4-40 x 0.875 inch 100° csk, FHS
	210-0406-00			1		NUT, hex., 4-40 x 0.188 inch
-21	378-0541-00			4		FILTER, lens
-22	333-1175-01			1		PANEL, front
-23	386-1528-00			1		SUBPANEL, front
-24	378-0603-00			1		FILTER, mesh
	- - - - - -			-		filter includes:
-25	367-0112-00			1		HANDLE
-26	213-0055-00			1		SCREW, 2-32 x 0.188 inch, PHS
-27	331-0259-00			1		GRATICULE
-28	200-0939-01			1		BEZEL
	- - - - - -			-		mounting hardware: *(not included w/bezel)*
-29	212-0518-00			4		SCREW, 10-32 x 0.313 inch, PHS
-30	214-0239-00[1]			2		THUMBSCREW
-31	210-0917-00[1]			2		WASHER, plastic, 0.250 ID x 0.500 inch OD
-32	354-0025-00[1]			2		RING, retaining
-33	367-0104-00[1]			2		HANDLE
	- - - - - -			-		mounting hardware for each: *(not included w/handle)*
-34	212-0506-00			2		SCREW, 10-32 x 0.500 inch, 100° csk, FHS
-35	407-0570-01[1]			2		BRACKET, angle
	- - - - - -			-		mounting hardware for each: *(not included w/bracket)*
-36	212-0506-00			2		SCREW, 10-32 x 0.375 inch, 100° csk, FHS
-37	334-1335-00[1]			1		PLATE, ident, left front
-38	334-1334-00[2]			1		PLATE, ident, right front
-39	367-0073-02[2]			1		HANDLE, carrying
	- - - - - -			-		mounting hardware: *(not included w/handle)*
-40	213-0155-00[2]			4		SCREW, 10-32 x 0.400 inch

[1]Type R4501 only

[2]Type 4501 only

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5	Description
1-41	386-1283-00[3]			2		PLATE
-42	200-0728-00[3]			2		COVER
-43	124-0221-00[3]			2		STRIP, trim
-44	426-0482-02			2		FRAME SECTION
	- - - - - -			-		mounting hardware for each: *(not included w/frame section)*
-45	212-0040-00			2		SCREW, 8-32 x 0.375 inch, 100° csk, FHS
-46	337-1122-01			1		SHIELD, CRT
	- - - - - -			-		mounting hardware: *(not included w/shield)*
-47	212-0004-00			2		SCREW, 8-32 x 0.313 inch, PHS
-48	210-0458-00			2		NUT, keps, 8-32 x 0.344 inch
-49	354-0314-02			1		RING, CRT, shockmount
	- - - - - -			-		mounting hardware: *(not included w/ring)*
-50	211-0590-00			4		SCREW, 6-32 x 0.250 inch, PHB
-51	210-0457-00			4		NUT, keps, 6-32 x 0.313 inch
-52	361-0286-00			3		SPACER
-53	131-0926-00			1		CONTACT ASSEMBLY, CRT
	- - - - - -			-		mounting hardware: *(not included w/contact assembly)*
-54	211-0110-00			4		SCREW, 4-40 x 0.313 inch, PHS
-55	210-0586-00			3		NUT, keps, 4-40 x 0.250 inch
-56	131-0373-00			3		CONNECTOR, terminal stand off
	- - - - - -			-		mounting hardware for each: *(not included w/connector)*
	210-0001-00			1		WASHER, lock internal #2
	210-0405-00			1		NUT, hex., 2-56 x 0.188 inch
-57	210-0259-00			1		LUG, solder, #2 SE
-58	348-0055-00			2		GROMMET, plastic, 0.250 inch
-59	343-0138-00			1		CLAMP, CRT
-60	352-0123-01			2		HOLDER, clamp
	- - - - - -			-		mounting hardware for each: *(not included w/holder)*
-61	211-0590-00			2		SCREW, 6-32 x 0.250 inch, PHB
-62	211-0599-00			2		SCREW, 6-32 x 0.750 inch, Fil HS
-63	220-0444-00			3		NUT, square, 6-32 x 0.250 inch
-64	343-0123-01			2		CLAMP
-65	211-0600-00			1		SCREW, 6-32 x 2 inch, Fil HS
-66	407-0591-00			1		BRACKET, CRT shield
	- - - - - -			-		mounting hardware: *(not included w/bracket)*
-67	210-0457-00			1		NUT, keps, 6-32 x 0.375 inch, PHS
	210-0559-00			1		SCREW, 6-32 x 0.375 inch, PHS
	212-0040-00			1		SCREW, 8-32 x 0.375 inch, 100° csk, FHS
	212-0043-00			1		SCREW, 8-32 x 0.500 inch, 100° csk, FHS
	210-0458-00			2		NUT, keps, 8-32 x 0.344 inch

[3]Type 4501 only

FIGURE 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
					1 2 3 4 5
1-68	348-0063-00			1	GROMMET, plastic, 0.500 inch
-69	129-0006-00			1	CONNECTOR, post
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-70	210-0205-00			1	LUG, solder, SE #8
-71	210-0045-00			1	NUT, keps, 8-32 x 0.344 inch
-72	175-0639-00			1	WIRE, CRT lead, brown
	175-0640-00			1	WIRE, CRT lead, blue
	175-0701-00			1	WIRE, CRT lead, green
	175-0702-00			1	WIRE, CRT lead, red
	- - - - - -			-	each wire includes:
	131-0049-00	B100000	B110569	1	CONNECTOR
	131-0883-00	B110570		1	CONNECTOR

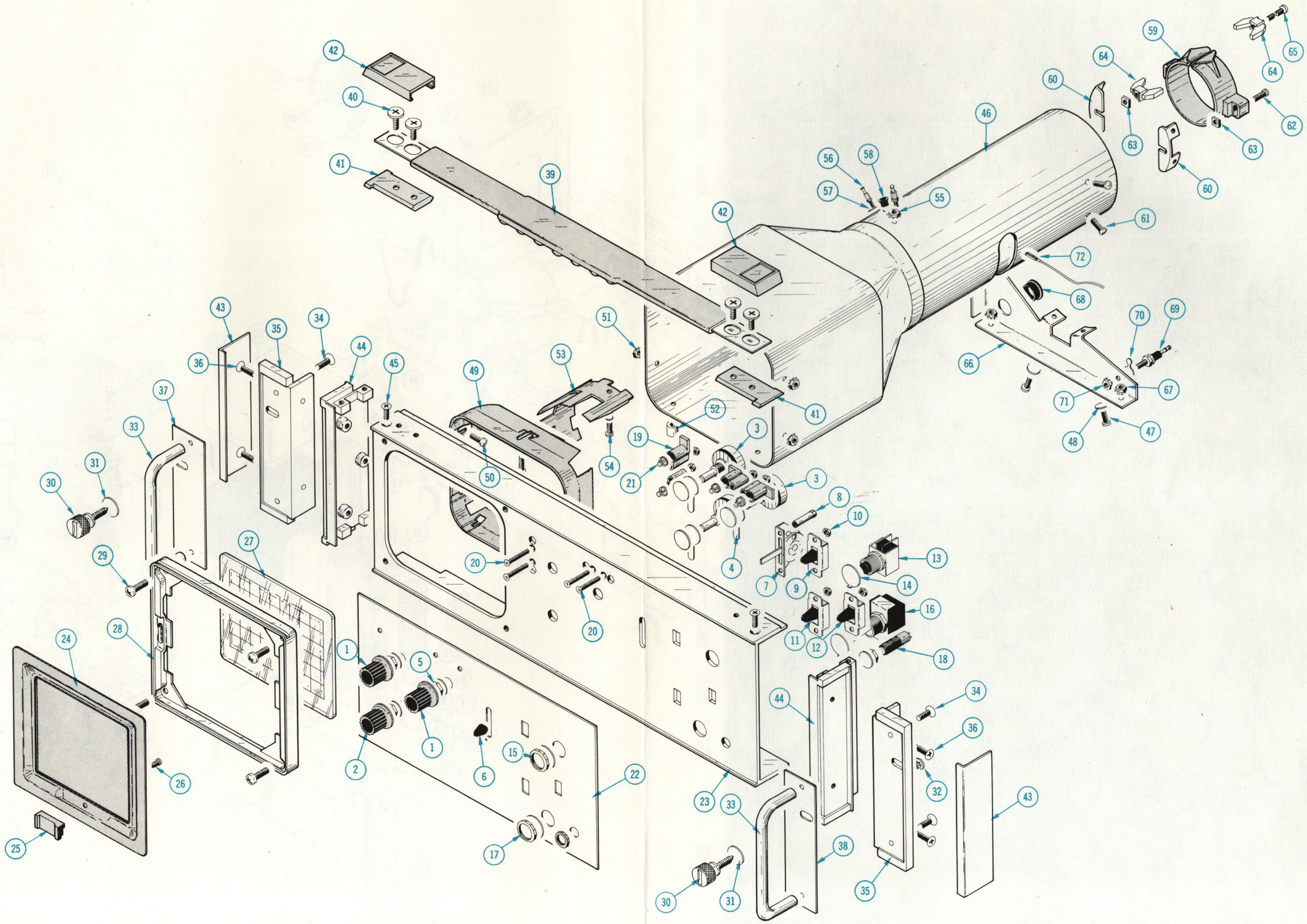

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72

FIG. 2 CHASSIS

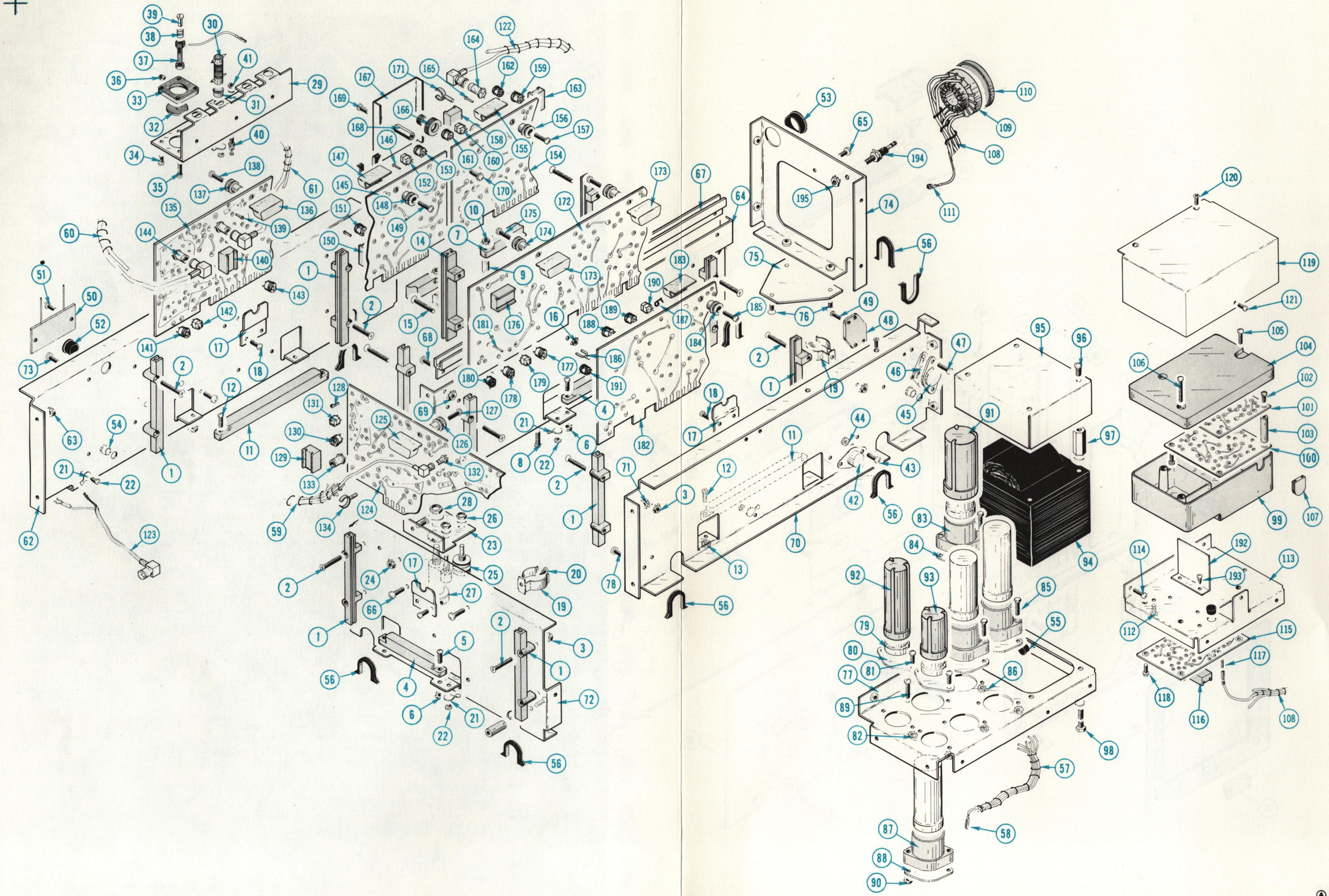


FIGURE 2 CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
2-1	351-0182-00			10	GUIDE, circuit board
	- - - - - -			-	mounting hardware for each: *(not included w/guide)*
-2	211-0109-00			2	SCREW, 4-40 x 0.875 inch, 100° csk, FHS
-3	210-0586-00			2	NUT, keps, 4-40 x 0.250 inch
-4	131-0327-00			1	CONECTOR, 30 pin female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-5	211-0014-00			2	SCREW, 4-40 x 0.500 inch, PHS
-6	210-0586-00			2	NUT, keps, 4-40 x 0.250 inch
-7	131-0327-00			2	CONNECTOR, 30 pin female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-8	211-0109-00			2	SCREW, 4-40 x 0.875 inch, 100° csk, FHS
-9	166-0033-00			2	SPACER
-10	210-0586-00			2	NUT, keps, 4-40 x 0.250 inch
-11	131-0292-01			3	CONNECTOR, 56 pin female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-12	211-0014-00			2	SCREW, 4-40 x 0.500 inch, PHS
-13	210-0586-00			2	NUT, 4-40 x 0.250 inch
-14	351-0183-00			1	GUIDE, circuit board, double
	- - - - - -			-	mounting hardware: *(not included w/guide)*
-15	211-0109-00			2	SCREW, 4-40 x 0.875 inch, 100° csk, FHS
-16	210-0586-00			2	NUT, 4-40 x 0.250 inch
-17	361-0235-00			3	RESTRAINT, circuit board
	- - - - - -			-	mounting hardware for each: *(not included w/restraint)*
-18	213-0088-00			2	SCREW, thread forming, 4-40 x 0.250 inch
-19	344-0117-00			2	CLIP, electrical
	- - - - - -			-	mounting hardware for each: *(not included w/clip)*
-20	213-0044-00			1	SCREW, thread forming, 5-32 x 0.188 inch, PHS
-21	210-0201-00			19	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: *(not included w/lug)*
-22	213-0044-00			1	SCREW, thread forming, 5-32 x 0.188 inch, PHS
-23	407-0592-00			1	BRACKET
	- - - - - -			-	mounting hardware: *(not included w/bracket)*
	211-0507-00			2	SCREW, 6-32 x 0.313 inch, PHS
-24	210-0457-00			2	NUT, keps, 6-32 x 0.313 inch

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
2-25	- - - - - -			2		RESISTOR, variable
	- - - - - -			-		mounting hardware for each: *(not included w/resistor)*
	210-0940-00			2		WASHER, flat, 0.250 ID x 0.375 inch OD
-26	210-0583-00			2		NUT, hex., 0.250-32 x 0.313 inch
-27	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: *(not included w/resistor)*
	210-0012-00			1		WASHER, lock, internal, 0.375 ID x 0.500 inch OD
	210-0978-00			1		WASHER, flat, 0.375 ID x 0.500 inch OD
-28	210-0590-00			1		NUT, hex., 0.375-32 x 0.438 inch
-29	407-0588-00			1		BRACKET
	- - - - - -			-		mounting hardware: *(not included w/bracket)*
	212-0004-00			3		SCREW, 8-32 x 0.250 inch, PHS
-30	- - - - - -			4		COIL
	- - - - - -			-		mounting hardware for each: *(not included w/coil)*
-31	354-0234-00			1		RING, mounting
-32	214-1138-00			4		HEATSINK
-33	352-0062-00			4		HOLDER, heatsink
-34	211-0008-00			8		SCREW, 4-40 x 0.250 inch, PHS
-35	211-0012-00			8		SCREW, 4-40 x 0.375 inch, PHS
-36	210-0406-00			16		NUT, hex., 4-40 x 0.188 inch
-37	343-0097-00			4		CLAMP
-38	214-0368-00			4		SPRING, helical compression
-39	210-0599-00			8		NUT, sleeve
-40	131-0373-00			4		CONNECTOR, terminal, stand off
	- - - - - -			-		mounting hardware for each: *(not included w/connector)*
	210-0001-00			1		WASHER, lock, internal #2
-41	210-0405-00			1		NUT, hex., 2-56 x 0.188 inch
-42	- - - - - -			1		THERMAL SWITCH
	- - - - - -			-		mounting hardware: *(not included w/thermal switch)*
-43	211-0504-00			2		SCREW, 6-32 x 0.250 inch, PHS
-44	210-0457-00			2		NUT, keps, 6-32 x 0.313 inch
-45	- - - - - -			1		TRANSISTOR
	- - - - - -			-		mounting hardware: *(not included w/transistor)*
-46	386-0978-00			1		PLATE
-47	211-0510-00			2		SCREW, 6-32 x 0.375 inch, PHS
-48	136-0135-00			1		SOCKET, transistor
	- - - - - -			-		mounting hardware: *(not included w/socket)*
-49	213-0113-00			2		SCREW, thread forming, 2-56 x 0.313 inch

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
2-50	- - - - - -			4	RESISTOR
	- - - - - -			-	mounting hardware for each: *(not included w/resistor)*
-51	210-0116-00			2	SCREW, sems, 4-40 x 0.313 inch, PHS
-52	348-0063-00			1	GROMMET, plastic, 0.500 inch
-53	348-0067-00			4	GROMMET, plastic, 0.313 inch
-54	348-0055-00			1	GROMMET, plastic, 0.250 inch
-55	348-0056-00			2	GROMMET, plastic, 0.625 inch
-56	358-0215-00			9	BUSHING, 0.658 x 0.625 inch
-57	179-1410-02			1	WIRING HARNESS, power
	- - - - - -			-	wiring harness includes:
-58	131-0371-00			15	CONNECTOR, terminal pin
-59	179-1411-01			1	WIRING HARNESS
-60	179-1415-00			1	WIRING HARNESS, X-amp
-61	179-1416-00			1	WIRING HARNESS, Y-amp
-62	441-0862-01			1	CHASSIS X-Y
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-63	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch
-64	441-0860-00			1	CHASSIS, Z axis, storage, read raster
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-65	212-0023-00			2	SCREW, 8-32 x 0.375 inch, PHS
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch
-66	212-0004-00			2	SCREW, 8-32 x 0.313 inch, PHS
-67	386-1628-00			1	SUPPORT, rail
	- - - - - -			-	mounting hardware: *(not included w/support)*
-68	211-0507-00			4	SCREW, 6-32 x 0.313 inch, PHS
-69	210-0457-00			4	NUT, keps, 6-32 x 0.313
-70	441-0858-00			1	CHASSIS, low voltage
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
	212-0023-00			2	SCREW, 8-32 x 0.375 inch, PHS
-71	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch
	212-0004-00			2	SCREW, 8-32 x 0.313 inch, PHS
-72	441-0861-00			1	CHASSIS, read ampl
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-73	212-0023-00			2	SCREW, 8-32 x 0.375 inch, PHS
	210-0458-00			2	NUT, keps, 8-32 x 0.344 inch
	212-0043-00			2	SCREW, 8-32 x 0.500 inch, 100° csk, FHS
-74	386-1695-00			1	SUPPORT, chassis
	- - - - - -			-	mounting hardware: *(not included w/support)*
	212-0004-00			4	SCREW, 8-32 x 0.313 inch, PHS

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
2-75	386-1694-00			1	PLATE
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-76	212-0070-00			3	SCREW, 8-32 x 0.313 inch, 100° csk, FHS
-77	441-0859-00			1	CHASSIS, transformer
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-78	212-0004-00			5	SCREW, 8-32 x 0.313 inch, PHS
	212-0043-00			3	SCREW, 8-32 x 0.500 inch, 100° csk, FHS
-79	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: *(not included w/capacitor)*
-80	386-0252-00			1	PLATE, capacitor insulating, small
-81	211-0507-00			2	SCREW, 6-32 x 0.313 inch, PHS
-82	210-0457-00			2	NUT, keps, 6-32 x 0.313 inch
-83	432-0048-00			3	BASE, capacitor mounting
	- - - - - -			-	mounting hardware for each: *(not included w/base)*
-84	386-0254-00			1	PLATE, capacitor insulating, large
-85	211-0588-00			2	SCREW, 6-32 x 0.750 inch, HHS
-86	210-0457-00			2	NUT, keps, 6-32 x 0.313 inch
-87	432-0048-00			1	BASE, capacitor mounting
	- - - - - -			-	mounting hardware: *(not included w/base)*
-88	386-0254-00			1	PLATE, capacitor insulating, large
-89	211-0516-00			2	SCREW, 6-32 x 0.875 inch, PHS
-90	210-0457-00			2	NUT, keps, 6-32 x 0.313 inch
-91	200-0293-00			1	COVER, capacitor, 2.500 inches high
-92	200-0255-00			1	COVER, capacitor, 3.000 inches high
-93	200-0256-00			1	COVER, capacitor, 2.000 inches high
	- - - - - -			1	Transformer
-94	- - - - - -			-	transformer includes:
-95	200-1051-00			1	COVER, transformer
-96	212-0518-00			4	SCREW, 10-32 x 0.313 inch, PHS
-97	384-0632-00			4	SPACER
	210-0812-00			4	WASHER, fiber, 0.1980 ID x 0.380 inch OD
	166-0434-00			4	TUBE, bolt, insulating
-98	212-0523-00			4	SCREW, 10-32 x 2.750 inches, HHS
	621-0443-00			1	ASSEMBLY, high voltage power supply
	- - - - - -			-	assembly includes:
-99	380-0115-00			1	HOUSING, HV supply
-100	670-0643-00			1	CIRCUIT BOARD ASSEMBLY—High Voltage (lower) A8
	- - - - - -			-	assembly includes:
	388-1174-00			1	CIRCUIT BOARD

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description
					1 2 3 4 5
2-101	670-0644-00			1	CIRCUIT BOARD ASSEMBLY—High Voltage (upper) A7
	- - - - - -			-	assembly includes:
	388-1175-00			1	CIRCUIT BOARD
	214-0579-00			1	PIN, test point
-102	211-0040-00			4	SCREW, 4-40 x 0.250 inch, BH nylon
-103	361-0137-00			2	POST, plastic
-104	200-0714-00			1	COVER
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-105	211-0507-00			1	SCREW, 6-32 x 0.313 inch, PHS
-106	211-0529-00			2	SCREW, 6-32 x 1.250 inch, PHS
-107	166-0319-00			3	SLEEVE
-108	136-0360-00			1	ASSEMBLY, CRT socket & cable
	- - - - - -			-	assembly includes:
-109	136-0202-01			1	SOCKET, CRT
-110	200-0616-00			1	COVER, CRT socket
	131-0049-00	B100000	B110569	1	CONNECTOR
	131-0883-00	B110570		1	CONNECTOR
-111	131-0371-00			8	CONNECTOR, terminal pin
-112	211-0507-00			3	SCREW, 6-32 x 0.313 inch, PHS
-113	441-0857-00			1	CHASSIS, high voltage
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-114	211-0507-00			2	SCREW, 6-32 x 0.313 inch, PHS
	211-0559-00			2	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
-115	670-0645-00			1	CIRCUIT BOARD ASSEMBLY—MODULATOR A6
	- - - - - -			-	assembly includes:
	388-1176-00			1	CIRCUIT BOARD
-116	136-0269-00			1	SOCKET, 14 pin
-117	131-0633-00			25	CONNECTOR, terminal pin
	- - - - - -			-	mounting hardware: *(not included w/assembly)*
-118	211-0116-00			4	SCREW, sems, 4-40 x 0.313 inch, PHS
	210-0201-00			1	LUG, solder, SE #4
-119	337-1124-00			1	SHIELD, high voltage
	- - - - - -			-	mounting hardware: *(not included w/shield)*
-120	211-0101-00			2	SCREW, 4-40 x 0.250 inch, 100° csk, FHS
-121	211-0008-00			1	SCREW, 4-40 x 0.250 inch, PHS
-122	179-1417-00			1	WIRING HARNESS
-123	175-1082-00			1	CABLE, special purpose
-124	670-1369-00	B100000	B129999	1	CIRCUIT CARD ASSEMBLY—READ AMPL A5
	670-1369-01	B130000		1	CIRCUIT CARD ASSEMBLY—READ AMPL A5
	- - - - - -			-	assembly includes:
	388-1928-00			1	CIRCUIT BOARD
-125	367-0090-00			1	GRIP
	- - - - - -			-	mounting hardware: *(not included w/grip)*
-126	210-1062-00			1	WASHER, recessed
-127	213-0082-00			1	SCREW, thread cutting, 4-40 x 0.500 inch, PHS

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
2-128	214-0579-00			5		PIN, test point
-129	136-0269-00			7		SOCKET, 14 pin
-130	136-0235-00			5		SOCKET, transistor, 6 pin
-131	136-0220-00			14		SOCKET, transistor, 3 pin
-132	131-0391-00			1		CONNECTOR, coaxial, 50 Ω
-133	131-0754-00			1		CONNECTOR, coaxial, 75 Ω
-134	352-0100-00			6		HOLDER, variable resistor
	- - - - - -			-		mounting hardware for each: *(not included w/holder)*
	361-0007-00			1		SPACER, nylon
-135	670-0638-01	B100000	B119999	1		CIRCUIT CARD ASSEMBLY—X-Y AMPL A3
	670-0638-02	• B120000		1		CIRCUIT CARD ASSEMBLY—X-Y AMPL A3
	- - - - - -			-		assembly includes:
	388-1169-00	B100000	B119999	1		CIRCUIT CARD
	388-1169-01	B120000		1		CIRCUIT CARD
-136	367-0090-00			1		GRIP
	- - - - - -			-		mounting hardware: *(not included w/grip)*
-137	210-1062-00			1		WASHER, recessed
-138	213-0082-00			1		SCREW, thread cutting, 4-40 x 0.500 inch, PHS
-139	214-0579-00			2		PIN, test point
-140	136-0269-00			2		SOCKET, 14 pin
-141	136-0235-00			12		SOCKET, 6 pin
-142	136-0220-00			2		SOCKET, transistor, 3 pin
-143	136-0183-00			4		SOCKET, transistor, 3 pin
-144	131-0754-00			4		CONNECTOR, coaxial, 75 Ω
-145	670-0641-02			1		CIRCUIT CARD ASSEMBLY—STORAGE A4
	- - - - - -			-		assembly includes:
	388-1172-00					CIRCUIT CARD
-146	214-0579-00			3		PIN, test point
	131-0566-00			1		TERMINAL, link connecting
-147	367-0090-00			1		GRIP
	- - - - - -			-		mounting hardware: *(not included w/grip)*
-148	210-1062-00			1		WASHER, recessed
-149	213-0082-00			1		SCREW, thread cutting, 4-40 x 0.500 inch, PHS
-150	136-0269-00			1		SOCKET, 14 pin
-151	136-0237-00			1		SOCKET, 8 pin
-152	136-0220-00			8		SOCKET, transistor, 3 pin
-153	136-0183-00			6		SOCKET, transistor, 3 pin
-154	670-1348-00			1		CIRCUIT CARD ASSEMBLY—Z AXIS AMPL A2
	- - - - - -			-		assembly includes:
	388-1907-00			1		CIRCUIT CARD
-155	367-0090-00			1		GRIP
	- - - - - -			-		mounting hardware: *(not included w/grip)*
-156	210-1062-00			1		WASHER, recessed
-157	213-0082-00			1		SCREW, thread cutting, 4-40 x 0.500 inch, PHS

FIGURE 2 CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5 Description
2-158	136-0269-00			1	SOCKET, 14 pin
-159	136-0235-00			5	SOCKET, transistor, 6 pin
-160	136-0220-00			10	SOCKET, transistor, 3 pin
-161	136-0183-00			6	SOCKET, transistor, 3 pin
-162	136-0237-00			2	SOCKET, integrated circuit, 8 pin
-163	136-0269-00			1	SOCKET, integrated circuit, 14 pin
-164	131-0754-00			2	SOCKET, coaxial, 75 Ω
-165	214-0579-00			2	PIN, test point
-166	214-0761-00			2	HEATSINK
-167	337-1125-00			1	SHIELD
	- - - - - -			-	mounting hardware: *(not included w/shield)*
-168	385-0146-00			2	POST, spacer
-169	211-0503-00			2	SCREW, 6-32 x 0.188 inch, PHS
-170	211-0601-00			2	SCREW, sems, 6-32 x 0.313 inch, PHS
-171	352-0100-00			4	HOLDER, variable resistor
	- - - - - -			-	mounting hardware for each: *(not included w/holder)*
	361-0007-00			1	SPACER, nylon
-172	670-0640-00	B100000	B109999	1	CIRCUIT CARD ASSEMBLY—READ RASTER A1
	670-0640-01	B110000		1	CIRCUIT CARD ASSEMBLY—READ RASTER A1
	- - - - - -			-	assembly includes:
	388-1171-00			1	CIRCUIT CARD
-173	367-0090-00			2	GRIP
	- - - - - -			-	mounting hardware for each: *(not included w/grip)*
-174	210-1662-00			1	WASHER, recessed
-175	213-0082-00			1	SCREW, thread cutting, 4-40 x 0.500 inch, PHS
-176	136-0269-00			25	SOCKET, 14 pin
-177	136-0237-00			2	SOCKET, 8 pin
-178	136-0235-00			3	SOCKET, transistor, 6 pin
-179	136-0220-00			9	SOCKET, transistor, 3 pin
-180	136-0183-00			2	SOCKET, transistor, 3 pin
-181	214-0579-00			11	PIN, test point
-182	670-0639-00			1	CIRCUIT CARD ASSEMBLY—LV REGULATOR A9
	- - - - - -			-	assembly includes:
	388-1170-00			1	CIRCUIT CARD
-183	367-0090-00			1	GRIP
	- - - - - -			-	mounting hardware: *(not included w/grip)*
-184	210-1062-00			1	WASHER, recessed
-185	213-0082-00			1	SCREW, thread forming, 4-40 x 0.500 inch, PHS
-186	344-0154-00			1	CLIP, fuse
-187	343-0043-00			1	STRAP
-188	136-0237-00			1	SOCKET, 8 pin
-189	136-0235-00			9	SOCKET, transistor, 6 pin
-190	136-0220-00			5	SOCKET, transistor, 3 pin
-191	136-0183-00			10	SOCKET, transistor, 3 pin
-192	337-0971-00			1	SHIELD
	- - - - - -			-	mounting hardware: *(not included w /shield)*
-193	213-0044-00			2	SCREW, thread forming, 5-32 x 0.188 inch, PHS
-194	129-0006-00			2	CONNECTOR, post
	- - - - - -			-	mounting hardware for each: *(not included w/post)*
-195	210-0457-00			2	NUT, keps, 6-32 x 0.188 inch

FIGURE 3 REAR & CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
3-1	390-0089-01			1	CABINET TOP
	- - - - - -			-	cabinet top includes:
	214-0812-00			4	LATCH KIT, flush mount, 1/4 turn
	- - - - - -			-	latch kit includes:
	386-0226-00			1	PLATE, locking
	386-0227-00			1	PLATE, index
	214-0604-00			1	SPRING, latch
	214-0603-01			1	PIN, securing
-2	390-0090-00			1	CABINET BOTTOM
	- - - - - -			-	cabinet bottom includes:
	214-0812-00			4	LATCH KIT, flush mount, 1/4 turn
	- - - - - -			-	latch kit includes:
-3	386-0226-00			1	PLATE, locking
-4	386-0227-00			1	PLATE, index
-5	214-0604-00			1	SPRING, latch
-6	214-0603-01			1	PIN, securing
-7	426-0488-00			1	FRAME SECTION, left
-8	426-0489-00			1	FRAME SECTION, right
-9	348-0080-01[4]			4	FOOT
	- - - - - -			-	mounting hardware for each: *(not included w/foot)*
-10	211-0510-00			1	SCREW, 6-32 x 0.375 inch, PHS
-11	426-0482-01			2	FRAME SECTION, rear
-12	212-0043-00			6	SCREW, 8-32 x 0.500 inch, 100° csk, FHS
-13	124-0221-00			2	STRIP, trim
-14	426-0490-00			1	FRAME SECTION, cabinet, top rear
-15	426-0491-00			1	FRAME SECTION, cabinet, bottom rear
-16	407-0589-00			1	BRACKET, angle
	- - - - - -			-	mounting hardware: *(not included w/bracket)*
-17	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
-18	407-0590-00			1	BRACKET, angle
	- - - - - -			-	mounting hardware: *(not included w/bracket)*
	211-0559-00			3	SCREW, 6-32 x 0.375 inch, 100° csk, FHS
-19	210-0201-00			2	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: *(not included w/lug)*
-20	213-0044-00			1	SCREW, thread foorming, 5-32 x 0.375 inch, PHS
-21	- - - - - -			4	TRANSISTOR
	- - - - - -			-	mounting hardware for each: *(not included w/transistor)*
-22	386-0978-00			4	PLATE, mica, insulating
-23	211-0510-00			2	SCREW, 6-32 x 0.375 inch, PHS
-24	136-0135-00			4	SOCKET, transistor
	- - - - - -			-	mounting hardware for each: *(not included w/socket)*
-25	213-0113-00			2	SCREW, thread forming, 2-32 x 0.188 inch, PHS

[4]Type 4501 only

FIGURE 3 REAR & CABINET (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description
3-26	- - - - - -			3	TRANSISTOR
	- - - - - -			-	mounting hardware for each: *(not included w/transistor)*
-27	386-0143-00			1	PLATE, mica, insulating
-28	213-0104-00			2	SCREW, thread forming, #6 x 0.375 inch, THS
-29	136-0270-00			3	SOCKET, transistor
	- - - - - -			-	mounting hardware for each: *(not included w/socket)*
-30	213-0088-00			2	SCREW, thread forming, 4-40 x 0.250 inch, PHS
-31	343-0089-00			1	CLAMP
-32	200-0500-00			2	COVER, transistor
	- - - - - -			-	mounting hardware for each: *(not included w/cover)*
-33	211-0034-00			2	SCREW, 2-56 x 0.500 inch, RHS
-34	131-0572-00			1	CONNECTOR, 3 wire, motor base
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-35	211-0542-00			2	SCREW, 6-32 x 0.313 inch, THS
-36	210-0457-00			2	NUT, keps, 6-32 x 0.313 inch
-37	131-0408-00			1	CONNECTOR, 37 pin female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-38	211-0101-00			2	SCREW, 4-40 x 0.250 inch, 100° csk, FHS
-39	210-0586-00			2	NUT, keps, 4-40 x 0.250 inch
-40	131-0569-00			1	CONECTOR, 25 pin, female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-41	211-0101-00			2	SCREW, 4-40 x 0.250 inch, 100° csk, FHS
	210-0586-00			2	NUT, keps, 4-40 x 0.250 inch
-42	260-0447-00			1	SWITCH, slide—MIX EXT VIDEO/INT VIDEO ONLY
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-43	211-0008-00			2	SCREW, 4-40 x 0.250 inch, PHS
-44	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-45	386-1527-00			1	PANEL, rear
	- - - - - -			-	mounting hardware: *(not included w/panel)*
-46	212-0075-00			8	SCREW, 8-32 x 0.250 inch, THS
-47	131-0274-00			6	CONNECTOR, coaxial, 1 contact BNC, insulated, w/hardware
-48	131-0126-00			9	CONNECTOR, coaxial, 1 contact BNC, w/hardware
-49	210-0241-00			10	TERMINAL, lug
-50	204-0279-00			1	BODY ASSEMBLY, line voltage selector
	- - - - - -			-	mounting hardware: *(not included w/body assembly)*
-51	210-0407-00			2	NUT, hex., 6-32 x 0.250 inch

FIGURE 3 REAR & CABINET (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
3-52	200-0762-00			1		COVER, line voltage selector
	- - - - - -			-		cover includes:
-53	352-0102-00			2		HOLDER, fuse
	- - - - - -			-		mounting hardware for each: *(not included w/holder)*
-54	213-0088-00			2		SCREW, thread cutting, 4-40 x 0.250 inch
-55	119-0215-00			1		FAN
	- - - - - -			-		mounting hardware: *(not included w/fan)*
-56	211-0511-00			4		SCREW, 6-32 x 0.500 inch, PHS
-57	378-0280-00			1		SCREEN
-58	385-0080-00			4		SPACER, hex., 0.500 inch
-59	378-0647-00			1		FILTER, air
-60	343-0263-00			1		RETAINER, filter
	- - - - - -			-		mounting hardware: *(not included w/retainer)*
-61	211-0565-00			4		SCREW, 6-32-0.250 inch THS
-62	200-0991-00			3		COVER, connector
	346-0045-00			3		STRAP, carrying
-63	367-0073-02[5]			1		HANDLE, carrying
	- - - - - -			-		mounting hardware: *(not included w/handle)*
-64	213-0155-00[5]			4		SCREW, 10-32 x 0.400 inch
-65	386-1283-00[5]			2		PLATE
-66	200-0728-00[5]			2		COVER,
-67	179-1412-00			1		WIRING HARNESS, voltage selector
-68	351-0104-00[6]			1		SLIDE, section, pair
	- - - - - -			-		mounting hardware: *(not included w/slide)*
-69	212-0004-00[6]			8		SCREW, 8-32 x 0.313 inch, PHS

[5]Type 4501 only
[6]Type R4501 only

FIG. 4 ACCESSORIES

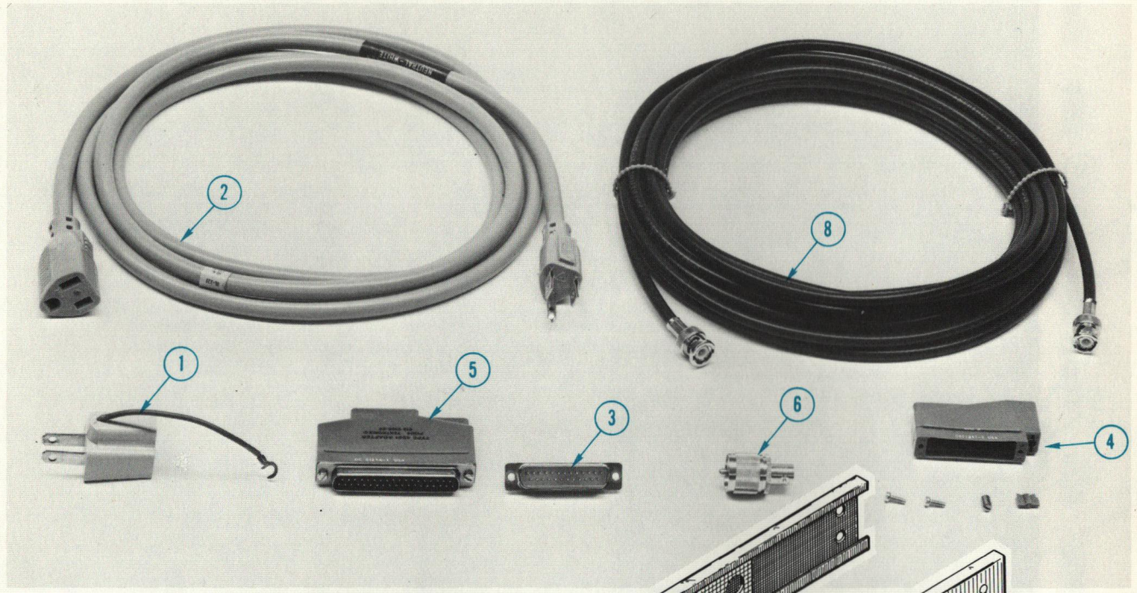
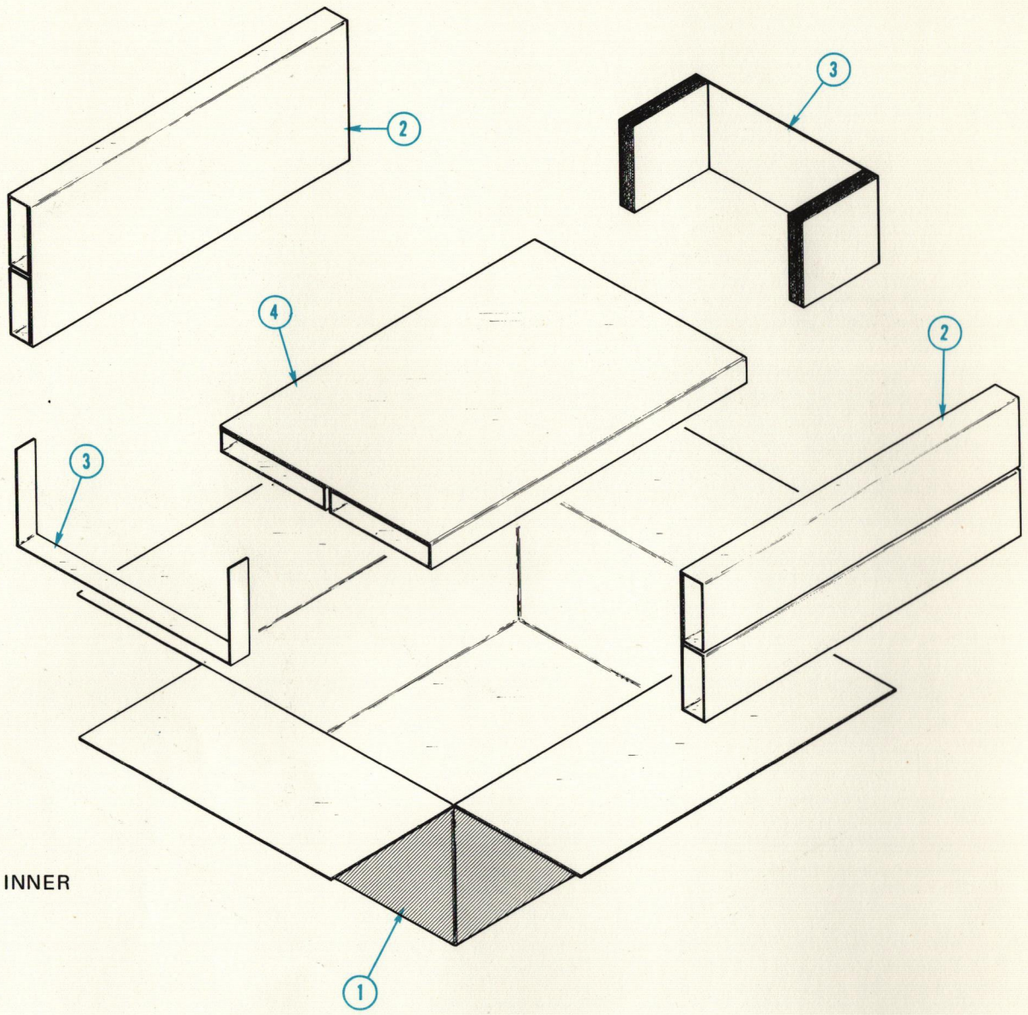


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty 1 2 3 4 5	Description
4-1	103-0013-00			1	ADAPTER, 3 to 2 wire
-2	161-0010-03			1	CORD, power
	131-0422-00			1	CONECTOR, 37 pin (not shown)
-3	131-0570-00			1	CONNECTOR, 25 pin, male
-4	200-0821-00			1	COVER, connector
-5	013-0108-00			1	ADAPTER, connector, loop thru
-6	103-0015-00			1	ADAPTER, UHF to BNC
-7	351-0241-00[7]			1	SLIDE ASSEMBLY
-8	012-0157-00			1	CABLE, 75 Ω BNC, 25 ft
	070-1158-00			1	MANUAL, instruction (not shown)

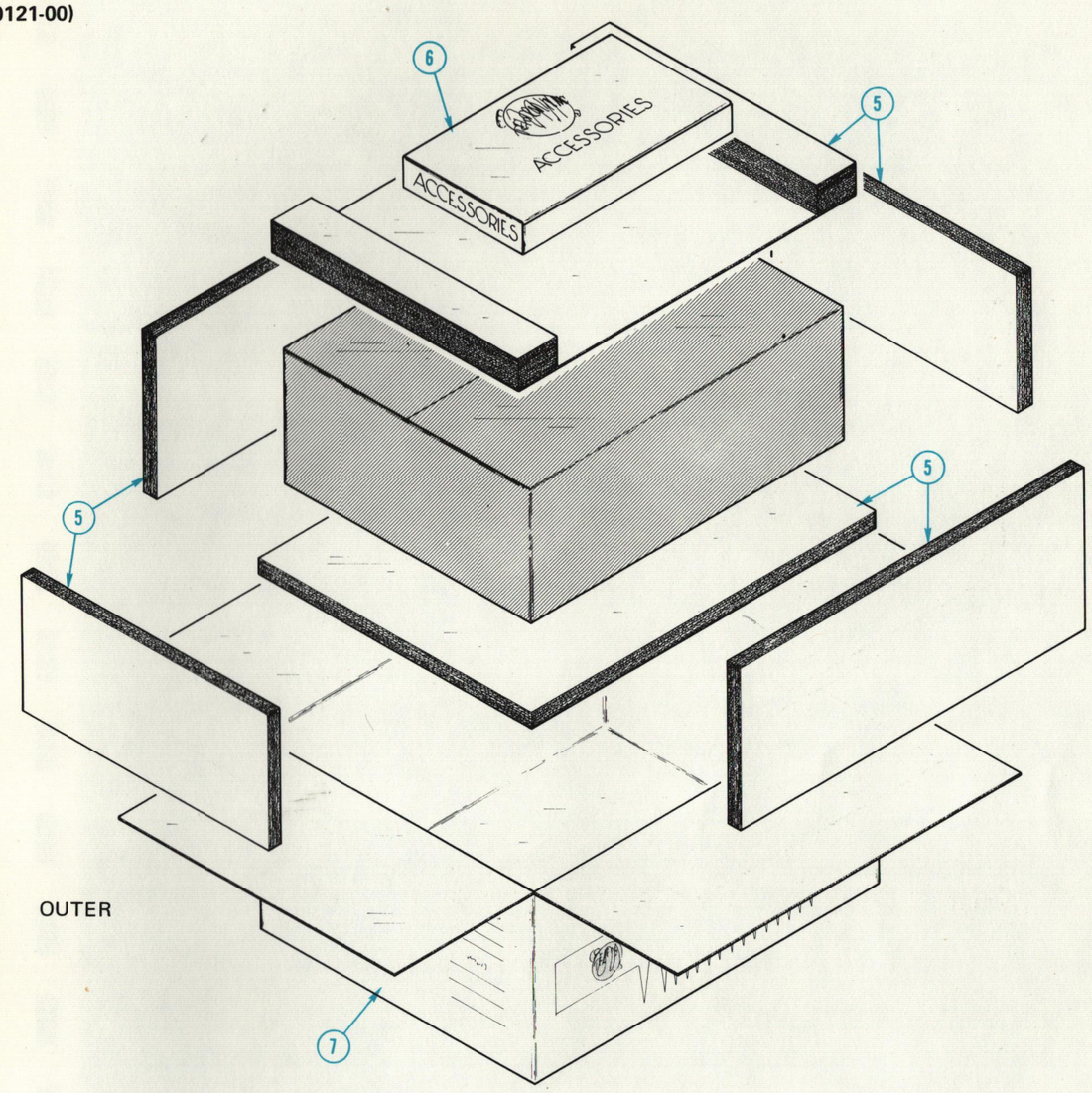
[7]Type R4501 only

CARTON ASSEMBLY
(Part No. 065-0121-00)



INNER

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5	Description
	065-0121-00			1		ASSEMBLY
	- - - - - -			-		assembly includes:
1	004-0460-00			1		CARTON, inner
2	004-0360-00			1		PAD SET, 2 piece
3	004-0359-00			1		PAD SET, 2 piece
4	004-0357-00			2		PAD



OUTER

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5	Description
-5	004-0361-00			1		PAD SET, 6 piece
-6	004-0462-00			1		CARTON, accessory
-7	004-0461-00			1		CARTON, outer

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

4501/R EFF SN B120000-up

ELECTRICAL PARTS LIST CORRECTION

CHASSIS

CHANGE TO:

J1 J2 J66 J131 J132 J158 J915 J1280 J1285 J1300 J1305 J1310 J1315 J1320 J1325	131-0955-00	BNC, receptacle, electrical

M17,603/572